PRACTICE EXAM 14: WPI/ABC WATER DISTRIBUTION OPERATOR SIMULATION (100 QUESTIONS)

1. A distribution system operator receives laboratory results showing the 90th percentile lead level from the most recent tap sampling round is 0.016 mg/L — just above the action level of 0.015 mg/L. The utility's corrosion control treatment maintains pH at 7.4 with orthophosphate at 0.8 mg/L. What is the most appropriate response?

A. Optimize the corrosion control treatment — the current pH and orthophosphate dose may be insufficient; adjusting pH upward to 7.88.0 and/or increasing orthophosphate to 1.01.5 mg/L can reduce lead leaching; additionally, the utility must begin public education about lead and initiate a lead service line replacement program as required

B. Issue a Tier 1 public notification and shut down the distribution system until lead levels drop below the action level

C. Resample at the same locations next quarter to verify the results before taking any action

D. The 0.001 mg/L exceedance is within measurement uncertainty and no action is required

2. A water system serves a community where a new elementary school has been built. The school's plumbing was installed with leadfree materials as required by current code. However, first draw testing at 15 school taps shows lead ranging from nondetect to 0.008 mg/L. What is the most likely source of the low level lead detected at some taps?

A. The school's service line contains a lead gooseneck at the corporation stop from a previous building that was demolished

B. The leadfree brass fixtures contain small amounts of lead (up to 0.25% under current leadfree standards) that can leach at low levels

C. Even "leadfree" brass fixtures and fittings contain small amounts of lead (up to 0.25% by weighted average under current standards) that can leach at low levels, particularly in new installations before a protective scale forms — the detected levels are well below the action level and are expected to decrease over time

D. The distribution main serving the school contains lead joints that are the source of the detected lead

3. A pump station has two identical centrifugal pumps in a lead lag configuration. The lead pump runs at 100% speed and produces 900 GPM at 110 feet of head. When both pumps run in parallel, the combined output is 1,580 GPM at 100 feet of head. Why did the head decrease from 110 to 100 feet when the second pump started?

A. The second pump is operating in reverse, reducing the total head in the system

B. The higher combined flow of 1,580 GPM creates more friction loss in the common discharge piping than the 900 GPM single pump flow — this higher system head forces both pumps to operate at a higher flow, lower head point on their performance curves

C. The VFD on the lead pump automatically reduced speed when the lag pump started to prevent overpressure

D. The lead pump's impeller is worn and cannot maintain head when the lag pump adds flow

4. An operator discovers that a customer has been receiving water through a 1940sera lead service line for decades. Recent first draw sampling shows lead at 0.042 mg/L — nearly three times the action level. The system's corrosion control is optimized with pH at 7.8 and orthophosphate at 1.2 mg/L. What should the utility recommend for this specific customer?

A. Continue the current corrosion control treatment and retest in 6 months to see if levels improve

B. Install a whole house carbon filter to remove the lead from all water entering the home

C. Advise the customer to flush the tap for 2 minutes before each use and test again in one year

D. Recommend lead service line replacement as the permanent solution — at 0.042 mg/L, the lead level far exceeds the action level despite optimized corrosion control; while flushing and pointofuse filters provide interim protection, removing the lead pipe permanently eliminates the source

5. A distribution system has a 750,000gallon elevated tank with a bowl diameter of 50 feet. SCADA shows the tank level dropping at 3.0 feet per hour during the afternoon peak. What is the approximate flow rate being drawn from the tank?

A. Approximately 44,055 gallons per hour — calculated as bowl area ($0.785 \times 50^2 = 1{,}963$ sq ft) × 3.0 ft = 5,890 cu ft × 7.48 gal/cu ft = 44,057 GPH

B. 22,440 gallons per hour based on using the radius instead of the diameter

C. 3,000 gallons per hour based on the drop rate without volumetric conversion

D. 5,890 gallons per hour based on the cubic foot volume without converting to gallons

6. A water system's treatment plant switches its primary coagulant from alum to ferric chloride. Within two weeks, distribution system customers throughout the system begin reporting brown water. The complaints come from all areas, not just one neighborhood. What is the most likely explanation?

A. Ferric chloride is passing through the treatment filters and entering the distribution system in its raw chemical form

B. The ferric chloride is reacting with the chlorine in the distribution system to form iron precipitates

C. The coagulant change has altered the finished water chemistry — potentially changing pH, alkalinity, or ionic balance — which has destabilized iron deposits on pipe surfaces throughout the system, causing widespread release of previously stable iron into the water

D. The brown water is caused by seasonal turnover in the source water reservoir that coincided with the coagulant change

7. An operator performing confined space entry into a belowgrade meter vault measures the atmosphere and obtains: O_2 = 20.9%, LEL = 0%, CO = 0, H_2S = 0. The vault has been open and ventilating naturally for 30 minutes. The operator enters, completes the meter change in 15 minutes, and exits. One hour later, another operator needs to enter the same vault. Is the original atmospheric reading still valid?

A. Yes, because the vault has been open for over an hour and conditions can only improve with continued ventilation

B. No — atmospheric conditions in confined spaces can change at any time; a new atmospheric test must be performed before each entry, regardless of how recently the last test was performed or how long the space has been open

C. Yes, as long as the vault has not been sealed or modified since the first entry

D. The original reading is valid for 4 hours per OSHA confined space regulations

8. A distribution system has two pressure zones. Zone 1 operates at 80 psi and feeds Zone 2 through a PRV set at 50 psi. During a fire in Zone 2, the fire department draws 2,200 GPM. Pressure in Zone 2 drops to 10 psi. The fire chief demands that the utility provide more water. What is the system limitation?

A. The fire trucks are not connected to the correct hydrant nozzle size for maximum flow

B. The pump station serving Zone 1 has lost one pump and cannot maintain full pressure

C. The fire department should connect to hydrants in Zone 1 instead of Zone 2 to access the higher pressure

D. The PRV station cannot pass 2,200 GPM at its setpoint — the station is the hydraulic bottleneck; the utility should consider installing a fire flow bypass around the PRV that opens automatically during high demand events to deliver Zone 1's full pressure to Zone 2

9. A water system's AMI data reveals that a commercial bakery's consumption has dropped from 15,000 gallons per day to zero overnight. The bakery is open and operating normally. The AMI transmitter shows "active" status with a signal strength of 95%. What is the most likely explanation?

A. The bakery has installed a private well and disconnected from the municipal supply without notification

B. The AMI transmitter has failed and is reporting zero consumption despite the meter registering normally

C. The water meter's measuring element has seized or failed — the bakery is consuming water, but the meter is not registering the flow; the AMI transmitter accurately reports the (zero) reading from the nonfunctioning meter

D. The bakery has voluntarily shut off its water supply for a plumbing renovation project

10. An operator calculates that a water system produces 3.8 MGD and the current chlorine dose is 2.0 mg/L using 12.5% sodium hypochlorite. How many gallons per day of the sodium hypochlorite solution are needed?

A. Approximately 60.7 gallons per day — calculated as: pounds of chlorine = $3.8 \times 2.0 \times 8.34 = 63.4$ lbs/day; gallons of 12.5% solution = $63.4 \div (8.34 \times 0.125) = 63.4 \div 1.043 = 60.8$

B. 63.4 gallons per day based on the pounds of chlorine equaling the gallons of solution

C. 507.2 gallons per day based on multiplying the chlorine pounds by 8.0

D. 7.6 gallons per day based on dividing the MGD by the dose

11. A distribution system serves a hospital that has reported intermittent pressure drops to 25 psi during peak morning hours. The hospital requires a minimum of 40 psi for medical equipment operation.

System pressure at the 12inch trunk main reads 64 psi during the same period. The hospital is served by a 4inch service line. What is causing the pressure loss?

A. The 12inch trunk main is severely tuberculated and cannot deliver adequate flow to the hospital area

B. A PRV at the zone boundary is malfunctioning and restricting flow during morning peak demand

C. The treatment plant reduces output during morning hours for routine filter maintenance

D. The hospital's peak morning demand creates high flow through the 4inch service line, generating 39 psi of friction loss between the main and the building — the service line is undersized for the hospital's current peak demand and should be upgraded to a larger diameter

12. A water operator discovers a wet area in a residential street that has been growing larger over the past two weeks. There is no surface evidence of the source — no open hydrant, no visible pipe, no construction activity. The wet area is located directly above a recorded 8inch distribution main. What should the operator investigate?

A. Whether a homeowner's irrigation system is leaking and sending water under the street surface

B. Whether the 8inch main has developed a leak that is migrating upward through the soil — the persistent, growing wet area directly above the main alignment is a classic indicator of a pressurized underground water leak; acoustic listening, correlating, or ground microphone surveys can confirm

C. Whether natural groundwater springs are surfacing due to recent rainfall

D. Whether the sanitary sewer beneath the street has backed up and is surfacing through the pavement

13. A water system's cross connection control inspector discovers that a car wash has connected its recycled water system (containing road grime, chemical detergents, acid wheel cleaner, and wax) to the potable supply for makeup water. The only protection is a single check valve. What corrective action is required?

A. Add a second check valve to create a double check valve assembly

B. The single check valve provides adequate protection for a car wash application

C. Install an RPZ assembly because the recycled water contains chemicals that represent a health hazard — acid wheel cleaner, chemical detergents, and road contaminants could cause illness if they entered the drinking water through backflow; a single check valve provides negligible protection for this highhazard connection

D. Install a PVB upstream of the connection because car washes create only backsiphonage conditions

14. A water system's operator is performing a specific capacity test on a well that has been in service for 20 years. The current results show: static water level = 60 feet, pumping water level = 132 feet at 400 GPM. Original well records show the pump produced 400 GPM with only 40 feet of drawdown when new. What do these results indicate?

A. The specific capacity has declined from 10.0 GPM/ft (400/40) to 5.6 GPM/ft (400/72) — a 44% decline indicating significant screen fouling, biofouling, or gravel pack deterioration that restricts the flow of water into the well; rehabilitation should be scheduled before the decline progresses further

B. The well is performing within normal parameters for a 20yearold installation

C. The increased drawdown is caused solely by regional aquifer depletion, not well deterioration

D. The pump has lost efficiency and is creating more drawdown than necessary to produce 400 GPM

15. A distribution system has a section of 6inch main that runs through an area with confirmed soil contamination from a former dry cleaning facility. The contamination includes perchloroethylene (PCE) at levels above the MCL in the groundwater surrounding the pipe. The main is PVC. What is the specific concern?

A. PCE will corrode the PVC pipe wall, causing structural failure within months

B. The PCE contamination will increase the chlorine demand inside the pipe, depleting the residual

C. PCE vapors will enter the distribution system through air release valves at nearby high points

D. PCE in contaminated soil and groundwater can permeate through the PVC pipe wall at the molecular level, entering the drinking water and potentially exposing customers to a known carcinogen at concentrations that may exceed the MCL

16. A pump station operator notices that the lead pump's discharge pressure has been gradually declining — from 88 psi six months ago to 81 psi today. The flow rate is constant at 750 GPM, motor amperage is unchanged, and suction conditions are stable. What is the most likely cause?

A. The SCADA discharge pressure transducer has drifted out of calibration over six months

B. Progressive wear on the pump's impeller and wear rings is allowing increasing internal recirculation — the pump does the same total work (constant amperage) but delivers less net pressure as more water leaks internally from the high pressure side back to the suction

C. The discharge piping has developed increasing scale buildup that creates more friction

D. The motor is gradually losing speed due to bearing wear, reducing energy transfer to the water

17. An operator is asked to explain why the utility adds both a disinfectant (chlorine) and a corrosion inhibitor (orthophosphate) to the water. A council member argues that one chemical should be sufficient. What is the correct response?

A. Both chemicals serve the same function and the council member is correct that one could be eliminated

B. The chlorine is added only at the treatment plant while the orthophosphate is added only in the distribution system

C. Chlorine kills harmful microorganisms to protect public health, while orthophosphate forms a protective coating on pipe surfaces to prevent lead, copper, and iron from dissolving into the water — these are completely different functions, and neither chemical can perform the other's role

D. Orthophosphate is added primarily to improve the taste of the water, not for corrosion control

18. A water main installation project requires connecting new 8inch ductile iron pipe to an existing 8inch cast iron main. The operator knows that CI and DI pipe have different outside diameters for the same nominal size. What fitting is needed?

A. A transition coupling designed to accommodate the different outside diameters — these couplings have different sized gaskets or adjustable glands on each end to bridge the dimensional difference between the two pipe materials

B. A standard mechanical joint coupling that fits both pipe types identically

C. A flanged adapter that requires welding on the cast iron side

D. The pipes have identical dimensions and no special fitting is needed

19. A distribution system's SCADA trend shows that an elevated tank's water level has been slowly rising for three hours even though all pump status indicators show "off." The tank level has increased by 4 feet. What should the operator investigate?

A. Whether the SCADA level sensor has malfunctioned and is showing a false rising trend

B. Whether rainwater is entering the tank through a compromised roof hatch or deteriorated vent screen

C. Whether thermal expansion from warming ambient temperatures has caused the water to expand

D. Whether a pump is actually running despite showing "off" status (feedback failure), or whether water from a higher pressure source is flowing into the tank through the open distribution network — the operator should physically verify pump status and check whether another zone's higher HGL is feeding water backward through an interconnection

20. A water system's operator is reviewing the utility's chemical delivery log and discovers that the sodium hypochlorite delivery driver accidentally pumped 150 gallons of sodium hypochlorite into the fluoride storage tank before the error was caught. The fluoride pump was running during the error. What must the operator determine immediately?

A. Whether the delivery driver has been trained on proper chemical delivery identification procedures

B. How much of the contaminated mixture was fed into the system before the error was discovered, what the resulting chlorine and fluoride concentrations were in the treated water, and whether any water quality impacts occurred — the contaminated tank must be taken offline, drained, and cleaned before the fluoride system is returned to service

C. Whether the fluoride chemical's expiration date has passed, making it incompatible with the hypochlorite

D. Whether the delivery company's insurance will cover the cost of the wasted chemicals

21. A distribution system serves a commercial greenhouse that has a direct connection between the potable supply and a fertigation system. The fertigation system injects concentrated liquid fertilizer into the irrigation lines using a chemical injection pump that operates at pressures above the municipal supply. What backflow prevention is required?

A. A PVB because the fertigation system creates only intermittent backsiphonage risk

B. A DCVA because fertilizer is classified as a lowhazard chemical additive

C. No protection is needed because the chemical injection pump includes internal check valves

D. An RPZ assembly because the fertigation system creates both a chemical hazard (fertilizer injection) and a backpressure condition (injection pump operates above supply pressure)

22. A water operator measures the chlorine residual at a monitoring point and obtains free chlorine = 0.0 mg/L and total chlorine = 0.0 mg/L. The monitoring point is on a 4inch deadend main that serves 5 residences. The normal residual at this location is 0.6 mg/L. What immediate action should the operator take?

A. Record the result and schedule the location for retesting next week

B. Flush the dead-end main immediately through the nearest hydrant or blowoff until an adequate chlorine residual is restored — zero residual means the water has lost all disinfection protection and is vulnerable to microbial contamination; the operator must also investigate why the residual was depleted

C. Increase the treatment plant chlorine dose by 25% to push more residual to this location

D. Collect a bacteriological sample and wait for results before taking any operational action

23. A water system's emergency generator at the main pump station is tested monthly under load as recommended by the manufacturer. During the April test, the generator starts and runs under load but produces only 70% of its rated power output. The maintenance technician diagnoses a fuel injector problem and schedules repair for the following week. Before the repair is completed, a power outage occurs. What is the operational impact?

A. The generator can operate at 70% output indefinitely and will provide adequate power for all pumps

B. The 70% output is sufficient because the pump station never operates at more than 60% capacity

C. The generator at 70% output may not be able to support all pumps simultaneously — the operator must prioritize which pumps to run, potentially leaving the system unable to maintain full pressure during the outage; this situation demonstrates why generator problems should be treated as urgent rather than routine maintenance

D. The power outage will cause the generator to fail completely because the fuel injector problem prevents starting under emergency conditions

24. An operator calculates the detention time of a 300,000gallon ground level reservoir that receives water at 500 GPM and supplies a zone with 500 GPM average demand. What is the theoretical turnover time, and what does it indicate about water quality?

A. 10 hours (300,000 ÷ 500 ÷ 60 = 10), meaning the tank turns over approximately 2.4 times per day — this is adequate for maintaining residual and limiting DBPs, but actual mixing efficiency determines whether the theoretical turnover represents true water replacement throughout the entire tank volume

B. 600 hours based on dividing gallons by GPM directly without converting to hours

C. 1 hour based on dividing the reservoir volume by the zone's peak hour demand

D. Detention time cannot be calculated without knowing the reservoir's exact dimensions

25. A distribution system serves a fire station that has a direct connection from the municipal supply to a fire truck quick fill system. The system includes a large diameter fill connection and a booster pump that pressurizes the fill line above municipal supply pressure. Fire trucks may carry water contaminated with firefighting foam, chemical runoff, and biological hazards. What backflow protection is required?

A. No protection is needed because fire stations are government facilities exempt from cross connection requirements

B. A DCVA provides adequate protection for fire truck fill systems at government facilities

C. A PVB at the fill connection because the system involves primarily back siphonage risk

D. An RPZ assembly — the fill system's booster pump creates backpressure above supply, and fire trucks carry water potentially contaminated with hazardous materials; this high hazard, backpressure connection requires an RPZ or air gap

26. A water main break occurs at 3:00 AM on a 16inch transmission main. The operator arrives and finds a 4foot longitudinal crack gushing water at an estimated 4,000 GPM. SCADA shows the elevated tank level dropping rapidly. What is the operator's first priority?

A. Begin excavation at the break location to expose the pipe for emergency repair

B. Locate and close the isolation valves needed to stop the water loss — every minute of delay at 4,000 GPM means 4,000 additional gallons lost, further tank depletion, and increasing risk of systemwide pressure loss

C. Contact the media to prepare a public notification about potential service disruption

D. Open hydrants on the opposite side of the system to balance pressure distribution

27. A water system operator is asked to explain the concept of "firm capacity" to a new employee. The system has three pumps rated at 600 GPM each. What is the firm capacity?

A. Approximately 1,1001,150 GPM — the output of two pumps operating in parallel (slightly less than 1,200 GPM due to increased system head), which represents the system's capacity with the largest single pump out of service

B. 1,800 GPM because firm capacity equals the total output of all installed pumps

C. 600 GPM because firm capacity equals the output of a single pump

D. 900 GPM because firm capacity equals the average of one pump and two pumps

28. A confined space entry team completes atmospheric testing of a belowgrade valve vault and obtains acceptable readings. The entrant enters, works for 45 minutes, and reports feeling lightheaded. The continuous atmospheric monitor mounted at the entry point still shows acceptable readings. What should happen?

A. The entrant should take a 10minute break inside the vault and continue if the symptoms resolve

B. Tell the entrant to move to a different area of the vault where ventilation may be better

C. Evacuate the entrant immediately — symptoms of lightheadedness may indicate a hazardous condition that the monitor at the entry point is not detecting, possibly because the hazard exists at a different location within the vault; the entrant's symptoms take priority over instrument readings

D. Send the attendant into the vault to check the atmospheric readings closer to where the entrant is working

29. A distribution system serves a university campus with research laboratories that use radioactive isotopes, a swimming pool with chemical treatment, and a veterinary clinic handling animal waste and pharmaceuticals. What level of backflow protection is required at the campus's main service connection?

A. A DCVA because the campus's primary function is educational, which is classified as low hazard

B. An RPZ assembly because the campus has multiple moderate hazard connections

C. A PVB because the campus connections involve primarily back siphonage risk

D. An air gap or RPZ at the main service connection — the presence of radioactive materials represents the highest possible hazard level and determines the protection required at the premises isolation point; individual high hazard connections within the campus should also have dedicated internal protection

30. A water system's elevated tank has an overflow elevation of 880 feet. A customer at elevation 795 feet complains of low pressure during peak demand. The operator measures 25 psi at the customer's

meter during peak. Under static conditions, what would the theoretical maximum pressure be at this customer's location?

A. 36.8 psi — calculated as (880 − 795) × 0.433 = 85 × 0.433 = 36.8 psi; this already marginal static pressure is further reduced during peak demand by friction losses, confirming the customer is near the upper service elevation limit for this zone

B. 85 psi based on the elevation difference alone without conversion to psi

C. 25 psi because the measured value always equals the static value at any given location

D. 196.4 psi based on multiplying the elevation difference by 2.31

31. An operator discovers that a 12inch gate valve serving as the primary isolation valve for a section with 1,500 customers has been buried under two inches of asphalt during a recent road paving project. The operating nut is completely inaccessible. What is the immediate operational concern?

A. During a main break emergency, this valve cannot be operated — the operator cannot isolate the break using this valve, forcing the use of more distant valves that affect a larger area and more customers; the valve must be raised to grade immediately as an emergency priority

B. The asphalt will corrode the valve box casting over time but does not affect the valve's current operability

C. The buried valve is only a concern during planned shutdowns, not during emergencies

D. The paving contractor is financially responsible and the utility should wait for them to correct the problem

32. A water system's annual water audit reveals: production = 4.5 MGD, billed metered consumption = 3.4 MGD, authorized unmetered use = 0.15 MGD, apparent losses = 0.35 MGD, real losses = 0.60 MGD. What is the percentage of nonrevenue water?

A. 13.3% based on real losses only as a percentage of production

B. 7.8% based on apparent losses only as a percentage of production

C. 24.4%, calculated as (4.5 − 3.4) ÷ 4.5 × 100 = 1.1 ÷ 4.5 × 100 — this includes all water produced but not billed: authorized unmetered (0.15), apparent losses (0.35), and real losses (0.60), totaling 1.10 MGD

D. 21.1% based on subtracting only the billed consumption and dividing by the billed consumption

33. A water system experiences a cyberattack on its SCADA system. The attacker changes the chlorine feed rate from 2.5 mg/L to 0.0 mg/L at 11:00 PM. No operators are on site. The SCADA display shows the chlorine residual at the plant gradually declining. What system design feature would have detected this attack earliest?

A. A firewall between the SCADA network and the internet that blocks all unauthorized connections

B. Encryption of all SCADA communications between field devices and the master station

C. A password policy requiring operators to change credentials every 30 days

D. A SCADA alarm configured to trigger whenever the chlorine feed rate setpoint changes by more than a specified threshold or when the residual drops below a minimum — this alarm would have notified the on call operator within minutes of the unauthorized change

34. A distribution system has a section of 20inch steel transmission main installed in 1975. The utility is evaluating its condition. What nondestructive inspection method can assess the pipe's wall thickness from inside the pipe without excavation?

A. Visual inspection using a closed-circuit television camera pushed through the main

B. An electromagnetic or ultrasonic inline inspection tool (smart pig) pulled through the pipe that measures remaining wall thickness, identifying areas of corrosion, pitting, and wall loss

C. Ground penetrating radar scanning from the surface above the main's alignment

D. Acoustic emission testing using hydrophones attached to hydrants to listen for active corrosion sounds

35. A water system's operator discovers that the utility's cross connection control program identified 600 commercial and industrial connections requiring backflow prevention devices. Of these, 400 have devices installed and tested annually. The remaining 200 have never been surveyed or protected. What is the most urgent action?

A. Survey and protect the 200 unassessed connections immediately — each unprotected connection represents an unknown hazard that could contaminate the municipal supply at any time; the 400 protected connections also require continued annual testing to verify their devices still function

B. Focus testing resources on the 400 existing devices because they represent known hazards with confirmed devices

C. Reduce the total number to 400 by removing the 200 unassessed connections from the program database

D. Defer the 200 unassessed connections until the next fiscal year when additional funding may be available

36. A water system serves an area where the soil is classified as severely corrosive (resistivity below 800 ohmcm). New ductile iron mains are being installed with polyethylene encasement. What additional corrosion protection should be considered for this extreme soil condition?

A. Painting the pipe exterior with an epoxy coating before installing the polyethylene wrap

B. Increasing the polyethylene wrap thickness from 8 mil to 12 mil for more robust protection

C. Installing cathodic protection (sacrificial anodes or impressed current) in addition to the polyethylene encasement — in severely corrosive soil, any breach in the encasement (from installation damage, soil settlement, or rock contact) exposes the pipe to aggressive attack; cathodic protection provides active electrochemical defense at these vulnerable points

D. Wrapping pipe joints with additional layers of polyethylene tape as a secondary seal

37. A pump station has three pumps. Pump 1 has accumulated 8,500 run hours, Pump 2 has 5,200 hours, and Pump 3 has 3,100 hours. The utility's policy calls for monthly lead pump rotation to equalize wear. What does this imbalance indicate?

A. Pump 1 is the most efficient and is naturally selected as lead more often by the SCADA system

B. The monthly rotation policy is not being consistently followed, or SCADA programming preferentially selects Pump 1

C. Pump 3 was offline for extended maintenance, creating the imbalance

D. The imbalance could result from multiple causes — inconsistent rotation execution, SCADA logic favoring Pump 1, extended downtime for Pump 3, or Pump 1 being in service longer before the rotation policy was implemented; the operator must investigate and correct the root cause to prevent premature failure of the overworked pump

38. A water system operates a well that produces water with naturally occurring iron at 0.5 mg/L (SMCL = 0.3 mg/L) and manganese at 0.08 mg/L (SMCL = 0.05 mg/L). Customers complain about reddish-brown staining and black deposits. Without installing treatment, what operational strategy could reduce complaints?

A. Increasing the chlorine dose to oxidize the iron and manganese before they reach customers

B. Blending the well water with a low iron, low manganese source to dilute both contaminants below their respective SMCLs — if another well or purchased water with lower mineral content is available, adjusting the blending ratio can bring the combined levels below the aesthetic thresholds

C. Flushing all dead-end mains weekly to remove accumulated iron and manganese deposits

D. Adding polyphosphate sequestrant to keep the iron and manganese in dissolved form to prevent staining

39. An operator calculates the velocity of water flowing through a 16inch main at 2,400 GPM. What is the approximate velocity?

A. Approximately 3.9 fps — calculated as (2,400 ÷ 448.8) ÷ (0.785 × 1.333^2) = 5.347 ÷ 1.396 = 3.83 fps; this is within the acceptable 25 fps range for normal distribution system operation

B. 7.7 fps, which exceeds the normal operating range and indicates the main may be undersized

C. 1.9 fps, which is below the minimum recommended velocity for preventing sediment settling

D. 15.3 fps, which would cause immediate pipe damage from excessive velocity

40. A water main installation project requires excavation in an area where the one call locate revealed five existing utilities within the trench zone: gas, electric, telephone, cable TV, and sanitary sewer. The water main is to be installed at 4.5 feet of cover. What is the most critical safety concern during this installation?

A. The number of existing utilities will make it impossible to achieve the required 4.5 feet of cover

B. The sanitary sewer may need to be relocated before the water main can be installed

C. The congested utility corridor requires careful hand digging around exposed utilities to prevent damage — striking a gas line creates an explosion hazard, cutting an electric line creates electrocution risk, and damaging a sewer line creates contamination risk; mechanical excavation must stop well before the marked locations of these utilities

D. The telephone and cable TV utilities must be relocated because they will interfere with future water main maintenance

41. A water system's SCADA alarm log shows that the same low-pressure alarm at Monitoring Point #12 has activated 55 times in the past month. Each alarm lasts approximately 20 minutes before

clearing. The on call operator has acknowledged each alarm without investigation. What systemic problems does this reveal?

A. The SCADA pressure transducer at Point #12 needs recalibration because it is generating false alarms

B. The alarm setpoint at Point #12 should be lowered to prevent future activations

C. Two systemic failures exist: (1) a recurring infrastructure problem causing 55 low-pressure events that has never been investigated or resolved, and (2) alarm fatigue causing the operator to dismiss alarms without investigation — both the physical infrastructure issue and the alarm response procedure must be addressed

D. The 55 alarms represent normal demand driven pressure variation that occurs in all distribution systems

42. A distribution system has a PRV station that reduces pressure from 90 psi (Zone 1) to 55 psi (Zone 2). The operator inspects the PRV and finds the downstream gauge reads 68 psi — 13 psi above the setpoint. What should the operator investigate?

A. Whether the PRV has a mechanical failure — the spring may have weakened, the diaphragm deteriorated, the pilot system malfunctioned, or debris on the seat is preventing full closure; any of these conditions can prevent the PRV from reaching its setpoint, allowing excess pressure to pass to Zone 2

B. Whether the downstream gauge needs recalibration because PRVs rarely malfunction

C. Whether the upstream Zone 1 pressure has increased, causing more water to push through the PRV

D. Whether a bypass valve around the PRV has been left partially open

43. A water system's operator receives quarterly disinfection byproduct results. Site #4 shows TTHM at 0.088 mg/L — above the MCL of 0.080. The LRAA at this site (using the past four quarters) calculates to 0.072 mg/L. Is the system in violation?

A. Yes, because any single quarterly result above the MCL is an automatic violation requiring public notification

B. Yes, because the LRAA should use only the two highest quarterly results

C. No, and no action is needed because the LRAA is comfortably below the MCL

D. No, because compliance is based on the LRAA (0.072), which is below the 0.080 MCL — however, the single high result of 0.088 is a serious warning that operational conditions at this monitoring site are

deteriorating; the operator must take immediate action to reduce water age and DBP formation before the next quarterly result pushes the LRAA above the MCL

44. An operator is calibrating a sodium hypochlorite metering pump. The pump is set to 60% stroke at 100 strokes per minute. During a 4minute timed calibration test, the operator collects 1,680 mL. What is the pump's output in gallons per hour?

A. 420 mL per minute, which exceeds the target output by approximately 5%

B. Approximately 6.66 gallons per hour — calculated as 1,680 mL ÷ 4 min = 420 mL/min; converting to GPM: 420 ÷ 3,785 = 0.111 GPM; converting to GPH: 0.111 × 60 = 6.66 GPH

C. 0.111 gallons per hour based on converting the per minute mL volume without multiplying by 60

D. 1,680 gallons per hour based on assuming 1 mL equals 1 gallon

45. A water system's treatment plant experiences a 2hour chlorine feed pump failure. During this period, unchlorinated water entered the distribution system. The failure is corrected and normal dosing resumes. What should the distribution operator do over the next 4872 hours?

A. No monitoring is needed because the 2hour gap is too short for significant contamination

B. Increase the treatment plant chlorine dose by 50% for one week to provide extra protection

C. Monitor chlorine residuals closely throughout the system, collect additional bacteriological samples from monitoring points near the point of entry and at representative system locations, and be prepared to flush areas where residual drops below minimum levels — the slug of unchlorinated water moving through the system could contain pathogens

D. Issue a systemwide boil water advisory as a precautionary measure until 72 hours of satisfactory samples are collected

46. A distribution system has two elevated tanks serving the same pressure zone. Tank A (overflow = 940 feet) consistently cycles between 75% and 95%. Tank B (overflow = 940 feet, same elevation) barely cycles — remaining between 88% and 93%. Both tanks are connected through the open distribution network. What is the most likely cause of Tank B's poor cycling?

A. The distribution piping between the two tanks has high friction loss — during fill cycles, most water flows to Tank A through lower resistance piping while Tank B, connected through higher resistance

piping, receives less inflow and minimal cycling; during drawdown, Tank A supplies most of the demand because water flows more easily from Tank A

B. Tank B has a stuck altitude valve that prevents water from entering or leaving freely

C. Tank B's level sensor has drifted and is not accurately reporting the actual water level changes

D. Tank B is larger than Tank A and naturally cycles less due to its greater volume

47. An operator is investigating a section of the distribution system where customers consistently report the lowest chlorine residuals and highest taste/odor complaints. The area is served by 40yearold unlined cast iron mains with numerous dead ends. Cfactor testing shows C = 55. What combination of factors explains the poor water quality?

A. The treatment plant is sending inadequate chlorine to this specific area

B. The customers in this area have unusually sensitive taste perception

C. A single large commercial customer in the area consumes chlorine through an internal cooling system

D. Multiple factors combine: the unlined cast iron's heavily corroded surface consumes chlorine rapidly (high pipe wall demand), the dead-end configuration prevents throughflow (creating stagnation and high water age), and the low Cfactor creates low velocity (allowing sediment settling and biofilm growth) — all factors compound to produce the worst water quality in the system

48. A water main repair crew is preparing to repair a 6foot longitudinal crack on a 12inch ductile iron main. The repair will use a full circle stainless steel repair sleeve. Before installing the sleeve, what critical step must the crew perform on the pipe surface?

A. Apply a primer to the pipe surface to help the sleeve gasket adhere to the pipe

B. Clean the pipe surface thoroughly with a wire brush to remove all dirt, corrosion, scale, and debris from the area where the sleeve gaskets will seat — any contamination beneath the gaskets creates leak paths that will cause the repair to fail under pressure

C. Score the pipe surface with a grinder to create texture for better gasket grip

D. Measure the exact crack length to ensure the sleeve is long enough, but cleaning is not necessary

49. A water system's operator discovers that the utility's emergency response plan lists an emergency interconnection with a neighboring utility that was decommissioned three years ago. The

interconnection valve has been permanently closed and the meter removed. The plan still counts on this interconnection for 800 GPM of emergency supply. What is the operational impact?

A. The utility's emergency response plan is based on a resource that no longer exists — if an emergency requires the 800 GPM from this interconnection, operators will discover too late that it is unavailable; the plan must be updated immediately, and alternative emergency supply arrangements must be made to replace the lost capacity

B. The decommissioned interconnection can be quickly reactivated by reopening the valve and reinstalling a meter

C. The loss of 800 GPM of emergency supply is insignificant relative to the system's total capacity

D. Emergency interconnections are never actually needed, so the outdated plan entry has no practical impact

50. A water system's operator is asked to calculate the weight of water in a cylindrical tank that is 40 feet in diameter and has a water depth of 25 feet. What is the approximate weight?

A. 31,400 cubic feet of water weighing approximately 1,959,360 pounds

B. 7,854 gallons weighing approximately 65,502 pounds

C. Approximately 1,959,360 pounds — calculated as $0.785 \times 40^2 \times 25 = 31,400$ cu ft; weight = $31,400 \times 62.4$ lbs/cu ft = 1,959,360 lbs (approximately 980 tons)

D. 234,872 gallons weighing approximately 1,958,833 pounds

51. A distribution system serves a hospital with a single 6inch water service connection. The hospital has 200 beds, an emergency department, surgical suites, and a dialysis unit. What is the most significant vulnerability this creates?

A. The 6inch service line may not be large enough to meet the hospital's peak demand

B. The hospital's fire sprinkler system may not receive adequate flow through a single 6inch service

C. The single service connection provides no redundancy — any failure, break, or planned maintenance on the service or the main it connects to completely eliminates water supply to the hospital

D. A single service connection with no redundancy creates the most critical vulnerability — any interruption on the 6inch service or its supply main leaves the hospital without water for patient care,

sterilization, fire suppression, and dialysis; a second, independent service connection from a different main is essential for a critical facility

52. A distribution system operator measures pressure at two hydrants on the same main during a period of steady flow. Hydrant A (elevation 620 feet) reads 58 psi. Hydrant B (elevation 650 feet, 2,000 feet downstream) reads 44 psi. What is the friction head loss between the two points?

A. 14 psi based on the simple difference between the two gauge readings

B. Approximately 2.4 feet — calculated by comparing HGL values: HGL_A = 620 + (58 × 2.31) = 754.0 ft; HGL_B = 650 + (44 × 2.31) = 751.6 ft; head loss = 754.0 − 751.6 = 2.4 feet

C. 32.3 feet based on converting the pressure difference to feet without accounting for elevation

D. 30 feet based on the elevation difference alone

53. A water system's operator is reviewing the utility's chemical storage practices and discovers that sodium hypochlorite and hydrofluosilicic acid (fluoride chemical) are stored in the same room without physical separation or individual secondary containment. What is the safety concern?

A. The two chemicals are fully compatible and can safely be stored in the same room

B. The chemicals will react through their storage tank walls even without direct contact

C. An accidental spill that allows the two chemicals to mix could produce toxic chlorine gas — chemical storage best practices require separating incompatible chemicals with physical barriers and individual secondary containment to prevent mixing from spills, delivery errors, or container failures

D. The only concern is that both chemicals require the same type of storage tank, creating potential delivery confusion

54. An operator is investigating a recurring pattern where the chlorine residual at a specific monitoring point drops to near zero every Monday morning but recovers to normal levels by Monday afternoon. The treatment plant dose is constant seven days per week. What is causing the Monday pattern?

A. Lower weekend demand means water reaching this point on Monday morning has sat in the system longer (higher water age) — the extended residence time allows more chlorine decay; when weekday demand increases, fresher water with higher residual reaches the point and levels recover

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

C. The sampling tap at the monitoring point is contaminated and should be replaced

D. A nearby business that is closed on weekends creates stagnation in the main that affects this monitoring point

55. A water system's elevated tank is taken out of service for rehabilitation. During the 6week outage, the pump station must operate continuously without the tank's equalizing capacity. What is the most critical operational risk during the outage?

A. Water quality will deteriorate because the tank provides essential mixing that improves residual

B. Customer pressure will fluctuate dramatically without the tank's stabilizing function

C. The pump motors will overheat from continuous operation without the cycling rest periods the tank normally provides

D. The system has no fire flow reserve — without the tank, the pump station must deliver fire flow instantaneously from its running pumps; if demand exceeds pump capacity or the pumps fail during a fire event, there is zero stored water to supplement the supply

56. A distribution system has a section of 8inch PVC main installed 15 years ago. Recent environmental testing has revealed petroleum contamination in the soil surrounding the pipe from a leaking underground storage tank at a nearby gas station. The contamination includes benzene, toluene, ethylbenzene, and xylene (BTEX compounds). What is the specific concern for the PVC water main?

A. The BTEX compounds will corrode the PVC pipe, causing structural failure

B. BTEX compounds and other petroleum hydrocarbons can permeate through PVC pipe walls at the molecular level, entering the drinking water inside the main and potentially exposing customers to carcinogenic compounds — PVC is known to be susceptible to permeation by petroleum products and organic solvents

C. The contaminated soil will increase the external loading on the PVC pipe, causing deflection

D. The gas station's underground storage tank will create pressure on the PVC pipe from the expanding contamination plume

57. An operator is performing a valve exercising round and encounters a 10inch gate valve that requires 30 turns to close. The valve record shows it should require 24 turns. After closing, the operator reopens and counts 24 turns to fully open. What do these observations indicate?

A. The valve stem has elongated from corrosion, adding extra turns on the closing stroke

B. The valve body has expanded from internal pressure, increasing the travel distance

C. Debris or sediment on the valve seat prevented the gate from fully seating during the normal 24 turns — the additional 6 turns compressed through or displaced the obstruction; the 24turn reopening confirms the correct mechanical travel once the seat was clear

D. The valve record is incorrect and should be updated to reflect 30 turns as the new standard

58. A water system's operator is developing a budget justification for a $150,000 leak detection survey. The utility's water audit shows production of 5.0 MGD and real losses of 0.85 MGD (17%). The utility's allin production cost is $3.00 per 1,000 gallons. What is the annual cost of the current real losses?

A. Approximately $930,750 per year — calculated as 0.85 MGD × 1,000,000 gal/MG × $3.00/1,000 gal × 365 days = $930,750; this annual loss far exceeds the onetime $150,000 survey investment

B. $2,550 per day, which annualizes to only $930 per year

C. $150,000 per year, coincidentally matching the survey cost

D. $465,375 per year based on using only half the real loss volume in the calculation

59. A water system's treatment plant switches its secondary disinfectant from free chlorine to chloramines. Before the conversion, what customer groups must be specifically notified?

A. Only commercial customers who use large volumes of water

B. Only customers with lead service lines because chloramines increase lead corrosion

C. No special notification is required as long as the total residual meets regulatory standards

D. Dialysis patients and facilities (chloramines are not removed by standard dialysis carbon filters and are toxic to blood), fish and aquarium owners (chloramines are lethal to aquatic life and are not removed by standing or standard carbon filtration), and businesses that depend on free chlorine for their processes

60. A distribution system has a 500,000gallon elevated tank that serves a residential zone. SCADA data shows the tank cycles between 80% and 95% during weekdays but barely moves (9195%) on weekends. Monday morning chlorine residuals at the tank outlet are consistently 0.4 mg/L lower than Friday evening levels. What operational change would improve Monday morning water quality?

A. Increase the chlorine dose at the treatment plant on Friday to compensate for weekend decay

B. Force deeper cycling of the tank on weekends by lowering the high level pump shutoff setpoint — this forces more water turnover through the tank during the low demand weekend, replacing stagnant water with fresh supply and maintaining higher residuals

C. Install a chlorine analyzer inside the tank to monitor residual decay in real time

D. The Monday morning residual drop is a normal characteristic that cannot be changed

61. A water system's operator is investigating a section of the distribution system where fire flow test results at a specific hydrant have declined steadily over eight years: 1,800 GPM → 1,600 → 1,400 → 1,200 → 1,100 → 950 → 850 → 750 GPM at 20 psi residual. The mains are 55yearold unlined cast iron. What does this progressive decline indicate?

A. The hydrant's internal mechanism is deteriorating, restricting its maximum discharge capacity

B. Progressive internal tuberculation is steadily reducing the mains' carrying capacity — the declining fire flow mirrors the declining Cfactor as the pipe interior becomes increasingly rough and restricted; at the current rate, the area will soon fail to meet minimum fire flow requirements

C. The pump station serving this area has been losing capacity year over year

D. Demand growth in the area has consumed the available hydraulic capacity

62. An operator calculates the head loss in a 2,500foot section of 10inch cement mortar lined ductile iron pipe (C=140) carrying 1,000 GPM. The Hazen Williams calculation yields approximately 9.4 feet. What is this in psi?

A. 21.7 psi based on multiplying feet by 2.31

B. 9.4 psi based on feet of head equaling psi directly

C. 1.25 psi based on dividing the head loss by 7.48

D. 4.1 psi, calculated as 9.4 feet × 0.433 psi/foot

63. A confined space entry team is preparing to enter a water storage tank for interior inspection. The tank was drained three days ago. Initial atmospheric testing at the access hatch shows: O_2 = 18.2%, LEL = 0%, CO = 0, H_2S = 0. What should the team do?

A. Do not enter — oxygen at 18.2% is below the 19.5% minimum; ventilate the space until oxygen exceeds 19.5%, identify the cause of the oxygen deficiency (possibly biological activity consuming oxygen from residual organic matter), and retest before allowing entry

B. Enter with air purifying respirators because the oxygen is only slightly below the minimum

C. Enter immediately because the LEL and toxic gas readings are all acceptable

D. Ventilate for 10 minutes and enter without retesting because ventilation always resolves oxygen deficiency

64. A water system serves a commercial building that has both a domestic water connection and a fire sprinkler connection. The sprinkler system contains stagnant water with chemical corrosion inhibitors and antifreeze in exposed piping sections. The sprinkler system is pressurized by a jockey pump above the municipal supply pressure. What backflow protection is required?

A. A DCVA because fire sprinkler systems are classified as low hazard

B. A PVB because the sprinkler system involves primarily back siphonage risk

C. An RPZ assembly — the antifreeze and chemical inhibitors represent a health hazard, and the jockey pump creates backpressure above the supply; this combination of chemical hazard plus backpressure requires the highest level of mechanical protection

D. No protection is needed because the jockey pump prevents backflow by maintaining positive forward pressure

65. A water system's operator discovers that an emergency interconnection valve with a neighboring utility was last exercised five years ago. The operator attempts to open the valve during a drought emergency and finds it completely seized. What lesson does this failure demonstrate?

A. Emergency interconnection valves should be replaced with actuated (motor operated) valves

B. All valves — including emergency interconnection valves that are normally closed — must be included in the regular valve exercising program to ensure operability when needed; a valve that sits closed for five years will likely seize, defeating the purpose of the interconnection precisely when it is needed most

C. The interconnection valve should have been replaced with a butterfly valve that is more resistant to seizing

D. The utility should drill a bypass around the seized valve to establish the emergency connection

66. A water system's treatment plant operator reports that raw water quality has suddenly deteriorated — turbidity has spiked from 2 NTU to 80 NTU due to heavy rainfall and runoff. The plant's filters are struggling to maintain compliance. What should the distribution system operator prepare for?

A. No preparation is needed because the treatment plant's filters will remove all turbidity

B. Begin flushing the entire distribution system immediately to make room for incoming turbid water

C. Reduce system pressure to slow the movement of turbid water through the distribution mains

D. Monitor residuals closely and prepare for potential turbidity breakthrough — if the plant cannot maintain the required turbidity limit, turbid water entering the distribution system will increase chlorine demand, deposit sediment in low velocity areas, and potentially shield pathogens from disinfection; prepare for targeted flushing in affected areas

67. An operator is asked to explain the difference between "static pressure" and "residual pressure" during a fire flow test. What is the correct distinction?

A. Static pressure is the pressure reading taken with no hydrants flowing — representing the system's pressure at rest; residual pressure is the pressure measured while water is being drawn from flow hydrants — representing the system's ability to maintain pressure under demand; the difference between static and residual indicates how much capacity the system has to deliver flow

B. Static pressure is always higher than residual pressure by a fixed percentage determined by the pipe diameter

C. Static pressure applies only to elevated tank systems while residual pressure applies only to pumped systems

D. Static pressure and residual pressure are interchangeable terms that describe the same measurement

68. A water system's annual budget includes $200,000 for distribution system maintenance, allocated across five programs. A board member proposes eliminating the $60,000 leak detection program and redirecting the funds to road paving. Last year's leak detection survey found 28 leaks with a combined estimated loss of 150 GPM. The utility's production cost is $3.50/1,000 gallons. What is the strongest argument against the proposal?

A. Leak detection is mandated by federal regulation and cannot be eliminated

B. The detected leaks collectively waste approximately 78.8 million gallons per year (150 GPM × 525,600 min/year)

C. Repairing the 28 detected leaks saves approximately $276,000 annually in production costs (78.8 million gallons × $3.50/1,000), representing a 4.6:1 return on the $60,000 investment — this financial return far exceeds any benefit from redirecting the funds to road paving

D. Leak detection provides valuable data for the GIS database that improves system mapping accuracy

69. A pump station operator notices that when both pumps run in parallel, the combined output is 1,650 GPM. Each pump produces 950 GPM individually. The operator expected approximately 1,800+ GPM from two pumps. What explains the 150+ GPM shortfall?

A. One pump has a worn impeller that is producing less than its rated flow when running alongside the other pump

B. The higher combined flow of 1,650 GPM increases friction in the common discharge piping compared to the 950 GPM single pump flow — this raised system head forces both pumps to operate at higher head, lower flow operating points on their curves; the shortfall is a normal characteristic of parallel operation

C. The SCADA flow meter is inaccurate at the higher combined flow rate and is reading approximately 150 GPM low

D. The pumps are hydraulically interfering with each other through the common suction piping

70. A water system's operator receives a complaint from a customer who reports persistent brown water that has not cleared after running the tap for 30 minutes. The customer's home is at the end of a deadend street. The operator opens the nearest hydrant and flushes for 20 minutes — the water clears. Four hours later, the customer calls again reporting the water has turned brown again. What does this recurrence indicate?

A. The customer's internal plumbing is the source of the brown water, not the distribution system

B. The hydrant flushing was not performed at a high enough velocity to effectively scour the main

C. The treatment plant is continuously sending brown water to this area

D. The dead-end main has severe internal tuberculation that continuously produces iron particles — flushing temporarily removes the discolored water, but the corroded pipe surfaces immediately begin shedding iron particles again; the permanent solution is cleaning and lining or replacing the deadend main

71. A water system's elevated tank has a capacity of 400,000 gallons. The zone's average daily demand is 1.0 MGD. What percentage of the average daily demand does the tank represent?

A. 4.0% based on dividing the tank volume by the daily demand in gallons

B. 400% based on dividing the daily demand by the tank volume

C. 40%, meaning the tank can hold 40% of one day's average demand — AWWA recommends equalization storage of 2550% of ADD; at 40%, this tank falls within the recommended range for equalization purposes

D. 2.5% based on dividing the tank volume by the annual production

72. An operator is troubleshooting a VFD controlled booster pump station where the discharge pressure oscillates between 50 and 70 psi with a 15second cycle period. The setpoint is 60 psi. What is the most likely cause?

A. The VFD's PID control loop is improperly tuned — the proportional gain is too high, causing the controller to overreact to each pressure deviation; each correction overshoots in the opposite direction, creating a sustained oscillation around the setpoint; reducing the proportional gain and adjusting the integral and derivative settings will stabilize the output

B. The pressure transducer has a loose electrical connection that creates intermittent signal drops

C. The pump's impeller is damaged and produces pulsating flow with each rotation

D. The suction piping has a partial blockage that creates intermittent flow restriction

73. A water system serves a community where a factory within the wellhead protection area has reported a release of trichloroethylene (TCE) — a volatile organic compound — from a leaking underground storage tank. The contamination plume is approximately 300 feet from the utility's production well. What immediate action should the operator take?

A. Continue operating the well and monitor for TCE in the next routine quarterly sample

B. Increase the well's pumping rate to dilute any TCE that may reach the well

C. Install carbon filtration at the well head to remove TCE before it enters the distribution system

D. Increase VOC monitoring frequency at the well, coordinate with the environmental agency overseeing the cleanup, and evaluate whether the well should be taken offline as a precautionary measure — an operating well's cone of depression can accelerate plume migration toward the well

74. A distribution system operator measures the following parameters at a pump station: suction pressure = 18 psi, discharge pressure = 85 psi. What is the total differential pressure the pump develops?

A. 85 psi based on the discharge reading alone

B. 67 psi, calculated by subtracting the suction pressure from the discharge pressure — this represents the pressure (head) the pump adds to the water; the suction pressure is energy already in the water before it enters the pump

C. 103 psi based on adding the suction and discharge pressures

D. 18 psi based on the suction pressure alone

75. A water system's operator discovers that a construction crew has installed new water mains in a residential subdivision without any tracer wire alongside the 8inch PVC pipe. The mains are backfilled and the streets are paved. Why is this omission significant?

A. Tracer wire is only required for metallic pipe, not PVC

B. Without tracer wire, the PVC pipe can still be located using ground penetrating radar with minimal difficulty

C. Without tracer wire, the PVC mains are invisible to standard electromagnetic locating equipment — any future excavation in the area risks striking the unmarked mains because excavators have no way to detect the pipe's location before digging

D. Tracer wire is an optional installation that provides convenience but is not required by standard specifications

76. A water system serves a neighborhood where customers report that their water looks "milky" but clears from the bottom up when left in a glass for 60 seconds. The affected customers are at the bottom of a steep hill. What causes this phenomenon?

A. The high pressure at the bottom of the hill (from the elevation head) forces more air into solution — when the water exits the tap at atmospheric pressure, the dissolved air rapidly comes out of solution as microscopic bubbles that create the milky appearance; the bubbles rise and dissipate, clearing the water from the bottom up

B. The milky water is caused by calcium carbonate precipitation from the lime used at the treatment plant

C. The steep hill creates velocity changes that introduce air at pipe connections along the slope

D. The customers' water heaters are overheating and creating steam bubbles in the cold water supply

77. A water system's SCADA trend data shows that daily water production has increased by approximately 2.5% per month for the past five months — from 3.0 MGD to 3.4 MGD. No new service connections have been added, and seasonal demand should be declining. What does this progressive increase indicate?

A. The treatment plant's production meter has drifted high by approximately 13% over five months

B. Customer consumption has gradually increased due to undetected changes in water use patterns

C. The elevated storage tank has developed a slow leak that is growing over time

D. A leak in the distribution system is developing and progressively worsening — the gradually increasing production compensates for water escaping through a growing leak; a leak detection survey should be initiated before the leak progresses to a catastrophic failure

78. An operator is performing a hydrant flow test. The static pressure at the residual hydrant is 58 psi. After opening two flow hydrants, the residual drops to 40 psi while the combined pitot measured flow is 1,000 GPM. Using Q_available = Q_tested × [(P_static − P_desired)/(P_static − P_residual)]^0.54, what is the available fire flow at 20 psi residual?

A. 2,000 GPM based on doubling the tested flow for the lower residual target

B. Approximately 1,367 GPM — calculated as 1,000 × [(58−20)/(58−40)]^0.54 = 1,000 × (38/18)^0.54 = 1,000 × 2.111^0.54 = 1,000 × 1.367

C. 1,000 GPM because the available flow always equals the tested flow

D. 500 GPM because the available flow is always half the tested flow at lower residual pressure

79. A water system operates a booster chlorination station at a remote location. The station uses a small sodium hypochlorite metering pump to inject chlorine into the main as water passes through. During a routine inspection, the operator finds the residual downstream of the station is 0.1 mg/L — far below the target of 0.8 mg/L. The pump shows "running" on its status indicator. What should the operator check first?

A. Whether the SCADA chlorine analyzer downstream needs recalibration

B. Whether the main upstream has experienced a break that is diluting the residual

C. Whether the sodium hypochlorite supply tank is empty or the chemical has degraded significantly — a pump that appears to be running but has no chemical to deliver, or severely degraded chemical with minimal available chlorine, will produce an inadequate residual despite appearing operational

D. Whether the injection quill is blocked with crystallized chemical deposits

80. A water system's operator is asked why the utility performs annual calibration of its production flow meters. What impact does an inaccurate production meter have on operations?

A. The production meter is the foundation for chemical dosing calculations, water audit accuracy, demand projections, and regulatory compliance — a meter reading 5% high causes chemical overdosing and underestimates water losses; a meter reading 5% low causes chemical underdosing and masks the true magnitude of system losses

B. Annual calibration is performed solely to maintain the meter manufacturer's warranty

C. Production meter accuracy only matters for utilities that sell wholesale water to other systems

D. The production meter's accuracy has no operational significance because customer meters track the actual consumption

81. A distribution system's SCADA alarm history shows that the same high temperature alarm on an elevated tank has activated every afternoon for the past two weeks during the hottest part of the day. The water temperature in the tank reaches 78°F at the peak. What water quality concern does this elevated temperature create?

A. The high temperature exceeds the SDWA maximum contaminant level for water temperature

B. The elevated temperature causes the pipe material to soften and release chemicals into the water

C. Water temperature has no effect on disinfectant residual or disinfection byproduct formation

D. Elevated water temperature accelerates chlorine residual decay (reducing protection against microbial contamination) and increases the rate of disinfection byproduct formation (TTHMs and HAA5) — the 78°F temperature also promotes nitrification in chlorinated systems and can support biological growth if residual drops too low

82. A water system's operator is preparing a capital improvement budget request. The system has 180 miles of water main, of which 40 miles are unlined cast iron installed before 1960. The remaining 140

miles are cement mortar lined ductile iron or PVC installed after 1960. The 40 miles of pre1960 cast iron account for 85% of all main breaks. What does this data support?

A. Replacing all 180 miles of main on a 100year replacement cycle

B. Prioritizing replacement investment on the 40 miles of pre1960 unlined cast iron — this 22% of the system generates 85% of the failures, and targeting these mains produces the greatest reduction in break rate per dollar invested

C. Replacing the 140 miles of post1960 main because it constitutes the majority of the system

D. Deferring all replacement until the entire system reaches 80 years of age

83. A confined space entry team is preparing to enter a large underground concrete reservoir that was drained two days ago. The reservoir normally stores chloramine treated water. Initial atmospheric testing shows: O_2 = 20.8%, LEL = 0%, CO = 0, H_2S = 0. The four gas monitor shows all readings within acceptable limits. What additional atmospheric hazard should the team evaluate?

A. Radon gas emanating from the concrete structure

B. Methane gas produced by bacterial decomposition of organic matter in the drained reservoir

C. Residual chloramine on wet surfaces can off gas ammonia and chlorine compounds — the standard four gas monitor does not detect these chemicals; a chlorine specific and/or ammonia specific detector is needed to evaluate this site specific hazard before entry

D. Carbon dioxide accumulating from concrete carbonation reactions

84. A water main installation project specifies restrained joints at all fittings on a new 10inch ductile iron main. The contractor installs standard push on joints at a 45degree bend, stating that the thrust block provides adequate restraint. The project specifications require restrained joints at all fittings. What should the operator/inspector require?

A. The contractor must install restrained joints as specified — regardless of whether the thrust block may also be adequate, the specifications require restrained joints at all fittings, and the contractor must comply with the project specifications as written

B. The thrust block is adequate and the contractor can continue with standard push on joints

C. The operator should accept the push on joints if the thrust block is properly sized and bearing against undisturbed soil

D. Only 90degree bends require restrained joints; 45degree bends can use standard push on joints

85. A water system's operator is evaluating two competing capital improvement projects. Project A replaces 2,000 feet of frequently breaking 4inch cast iron main serving 30 homes ($180,000). Project B rehabilitates all 4 pumps at the main pump station serving the entire 12,000connection system ($250,000). Only one project can be funded this year. Which should be prioritized?

A. Project A because it addresses an immediate, visible problem with the most customer complaints

B. Both projects should be deferred until they can be funded simultaneously

C. Project A should be prioritized because its lower cost allows more budget for other maintenance programs

D. Project B — rehabilitating the main pump station's 4 pumps affects the entire 12,000connection system; if the pumps fail, all customers lose water; the station wide consequence of pump failure far exceeds the impact of the 30home main break problem, which can be managed with reactive repairs in the interim

86. A water system experiences a confirmed waterborne disease outbreak traced to contamination entering the distribution system through an unprotected cross connection during a main break that caused negative pressure. What comprehensive program improvements should be implemented to prevent future events?

A. Install an RPZ assembly only at the specific connection that caused the contamination

B. Conduct a comprehensive survey of all commercial and industrial connections, install appropriate backflow prevention devices at all identified hazards, implement mandatory annual device testing, establish enforcement authority for noncompliance, launch public education, and increase operator training on cross connection recognition and emergency response

C. Focus on the affected customers only and install backflow devices on their individual service connections

D. Hire a consultant to write a new cross connection control plan and defer implementation to the next budget year

87. A water system's operator is asked to calculate how many gallons of 12.5% sodium hypochlorite are needed per day to treat 6.0 MGD at a chlorine dose of 2.2 mg/L. What is the answer?

A. 110.1 gallons per day based on the pounds formula result equaling the gallons needed

B. 13.8 gallons per day based on dividing the MGD by the dose concentration

C. Approximately 105.7 gallons per day — first calculating pounds of chlorine (6.0 × 2.2 × 8.34 = 110.1 lbs/day), then converting to gallons of 12.5% solution (110.1 ÷ 1.043 = 105.6 gallons/day)

D. 880.8 gallons per day based on multiplying the pounds of chlorine by 8.0

88. A water system's operator discovers that the utility's emergency response plan does not include a provision for communicating with non English speaking customers during a water quality emergency. The community has a significant Spanish speaking population. Why is this a critical gap?

A. Failing to effectively communicate health critical information to all customers — including those with limited English proficiency — leaves a significant portion of the service population unable to take protective action during an emergency, potentially resulting in illness and creating civil rights liability for the utility

B. Translation services are prohibitively expensive and cannot be justified in the emergency budget

C. Non English speaking customers represent a small percentage of the population and can rely on neighbors for translation

D. Emergency notifications are self-explanatory and do not require language specific communication

89. An operator performs a DPD chlorine test at a monitoring point in a chloramine system. The results show: free chlorine = 0.3 mg/L, total chlorine = 2.5 mg/L. What is the combined chlorine concentration, and what does the elevated free chlorine indicate?

A. Combined chlorine = 2.2 mg/L; the 0.3 mg/L free chlorine is within normal range for a chloramine system

B. Combined chlorine = 2.8 mg/L, calculated by adding free and total chlorine

C. Combined chlorine = 0.3 mg/L because free chlorine represents the combined fraction in chloramine systems

D. Combined chlorine = 2.2 mg/L (total minus free); the elevated 0.3 mg/L free chlorine suggests the chloramine may be partially degrading, potentially indicating an improper chlorinetoammonia ratio or

breakpoint conditions — this can produce taste and odor complaints from dichloramine and trichloramine formation

90. A distribution system serves a neighborhood at the highest elevation in the pressure zone. The elevated tank overflow is at 900 feet. The highest customer is at elevation 870 feet. Under static conditions, the maximum pressure = (900 − 870) × 0.433 = 13.0 psi. What does this mean for this customer?

A. The customer receives barely adequate pressure during off peak periods

B. The 13.0 psi static pressure is far below the 35 psi minimum recommended for normal service — even under perfect conditions with zero demand and zero friction loss, this customer cannot receive adequate pressure from this zone; the customer needs either a higher tank, a dedicated booster system, or reassignment to a higher pressure zone

C. The static pressure can be improved by increasing the pump station discharge pressure

D. The customer should install an internal booster pump at their own expense to supplement the inadequate system pressure

91. A water system's elevated tank has been inspected and found to have several areas of deteriorated interior coating with exposed steel showing active pitting. The deepest pit is 1/8 inch. The tank wall thickness is 5/16 inch (0.3125 inch). What percentage of the wall has been consumed by the deepest pit?

A. 12.5% of the wall thickness has been consumed (0.125 ÷ 5.0 × 100), which is not significant

B. 50% of the wall thickness has been consumed (0.125 ÷ 0.25 × 100), which would be critical

C. 40% of the wall thickness has been consumed (0.125 ÷ 0.3125 × 100 = 40%) — this is a significant structural concern; while 60% of the wall remains, the pitting creates a stress concentration that weakens the wall beyond what the remaining thickness alone would suggest; the tank needs recoating and the pits need structural evaluation

D. 25% of the wall has been consumed, which is within acceptable limits for tanks of this age

92. An operator is developing a training program for new distribution system operators. What topic should be covered FIRST before any field work begins?

A. Safety training — confined space entry, excavation safety, traffic control, lockout/tagout, chemical handling, and emergency response; these life safety topics must come before any field work because a single safety mistake can be fatal on the operator's first day in the field

B. SCADA system operation and data entry procedures

C. Hydraulic calculations and the Hazen Williams formula

D. Water quality sampling techniques and DPD testing procedures

93. A water system's operator discovers that the utility has been operating for 6 months with 3 of its 12 SCADA remote terminal units (RTUs) showing "communication failure." These 3 sites include a production well, a booster pump station, and a storage tank. What operational risk has existed for 6 months?

A. The communication failures have no operational impact because the sites operate on local automatic control

B. Minor inconvenience because operators can check these sites during routine weekly visits

C. The 3 sites represent a small percentage of the system and the communication failures are not operationally significant

D. For 6 months, the utility has been unable to remotely monitor or control these 3 critical facilities — alarms at these sites go undetected, tank levels are unknown, pump failures are not reported, and water quality changes are not captured; any emergency at these sites would be discovered only during a physical visit or when customers report problems

94. A water system's operator is asked to calculate the annual cost of electricity for a pump station that consumes 720 kWh per million gallons pumped and produces 3.5 MGD. The electricity rate is $0.11 per kWh. What is the approximate annual electricity cost?

A. $277,200 per year based on a simplified calculation

B. Approximately $101,000 per year — calculated as 720 kWh/MG × 3.5 MG/day × 365 days × $0.11/kWh = 720 × 3.5 × 365 × 0.11 = $101,124

C. $27,720 per year based on using only 100 operating days per year

D. $919,800 per year based on multiplying kWh/MG by gallons per day without proper unit conversion

95. A distribution system serves a community where a large portion of the system was built using asbestos cement (AC) pipe in the 1950s and 1960s. Workers are scheduled to perform a tap on an existing AC main for a new service connection. What specific safety precaution is required?

A. No special precautions are needed because AC pipe poses no health risk during maintenance

B. Workers should wear latex gloves to prevent skin contact with the asbestos fibers

C. Workers must use wet cutting techniques and wear appropriate respiratory protection (N100 or P100 half face respirator at minimum) to prevent inhalation of asbestos fibers released during cutting, drilling, or tapping operations — airborne asbestos fibers from dry cutting are a serious respiratory health hazard

D. The tap cannot be made on AC pipe and the main must be replaced with ductile iron before the service connection can be installed

96. A water system's operator is reviewing the utility's water loss control program and finds that all leaks have been found reactively — after they surfaced or were reported by customers. No proactive leak detection surveys have ever been conducted. Why is this approach inadequate?

A. The majority of water lost through distribution system leaks escapes through small, hidden, underground leaks that run for months or years without ever surfacing — proactive acoustic or correlating leak detection finds these invisible losses that reactive response completely misses

B. Reactive leak detection is actually the industry recommended approach and proactive surveys provide no additional benefit

C. Proactive detection is only beneficial for systems with more than 500 miles of main

D. Reactive detection finds all leaks eventually because they all surface within 30 days

97. A water system is planning to take its only elevated storage tank offline for six weeks of interior rehabilitation. The pump station must operate continuously without the tank. What preparations are essential?

A. Notify all customers that water service will be intermittent during the six week period

B. Install temporary aboveground storage tanks throughout the service area to replace the offline tank

C. Reduce the system operating pressure by 20% to conserve the water normally stored in the tank

D. Verify emergency backup power at all pump stations, configure pressure based pump controls, notify the fire department of reduced fire flow reserve, establish enhanced monitoring procedures, preposition

emergency repair materials, and ensure adequate staffing — the system has zero margin for error without the tank's pressure equalization, fire flow reserve, and emergency supply buffer

98. An operator receives a customer complaint about a persistent chlorine taste even though the residual at the customer's tap measures only 0.5 mg/L — well within the normal range. What should the operator suggest?

A. Tell the customer the chlorine level is safe and they should tolerate the taste

B. Acknowledge the customer's sensitivity, explain that the residual is normal and safe, and suggest practical remedies — filling a pitcher and refrigerating it allows chlorine to dissipate, or a carbon pitcher filter effectively reduces chlorine taste and odor while maintaining the safety benefit of the disinfectant throughout the distribution system

C. Reduce the systemwide chlorine dose to accommodate this customer's taste preference

D. Collect samples for laboratory analysis to determine if a contaminant other than chlorine is causing the taste

99. A water system serves a community where the utility's emergency generator at the main pump station has a 600gallon diesel fuel tank. The generator consumes 16 gallons per hour at full load. A winter storm causes a 72hour power outage. How many hours of operation does the fuel provide, and when must the operator arrange fuel delivery?

A. 600 hours based on the tank capacity alone

B. 37.5 hours (600 ÷ 16), which is approximately 34 hours short of the 72hour outage

C. The operator has 37.5 hours of fuel and should arrange delivery well before that point — ideally within the first 1824 hours — to maintain a reserve in case storm conditions delay the fuel truck; the generator's fuel consumption rate and the outage duration require proactive fuel management

D. The generator can run for 72 hours if the operator reduces the load by shutting down half the pumps

100. A retiring water distribution operator with 35 years of experience is asked what single piece of knowledge has been most valuable throughout their career. What would the experienced operator most likely say?

A. Knowing the system — every pipe, valve, hydrant, tank, and pump; understanding how water moves through the system under different demand conditions; recognizing how each component affects every other — this intimate knowledge of the physical infrastructure enables faster emergency response, better maintenance planning, smarter capital decisions, and more effective daily operations than any other single skill

B. Mastering the hydraulic formulas used on the certification exam

C. Learning to operate the SCADA system and GIS database efficiently

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

Practice Exam 14: Answer Key and Explanations

1. A — Exceeding the lead action level triggers a cascade of requirements: optimize corrosion control (adjusting pH upward and/or increasing orthophosphate), conduct public education about lead risks and protective measures, and initiate a lead service line replacement program. The current pH of 7.4 and orthophosphate of 0.8 mg/L may be insufficient — increasing to pH 7.8-8.0 and orthophosphate 1.0-1.5 mg/L can significantly reduce lead leaching.

2. C — Current "lead-free" standards allow up to 0.25% lead by weighted average in plumbing fixtures and fittings. New brass components can leach small amounts of lead, particularly before a protective mineral scale forms on the wetted surfaces. The detected levels (up to 0.008 mg/L) are well below the 0.015 action level and are expected to decrease over time as the fixtures condition.

3. B — When two parallel pumps operate, the combined flow increases velocity in the common discharge piping. Higher velocity creates more friction loss, raising the total system head that both pumps work against. Both pumps move to higher-head, lower-flow operating points on their curves. The head decreased from 110 to 100 feet because the system head curve rose with the increased combined flow.

4. D — At 0.042 mg/L — nearly three times the action level — the lead service line is the dominant source despite optimized corrosion control. While flushing before use and point-of-use filters provide interim risk reduction, physical removal of the lead pipe permanently eliminates the exposure pathway. Corrosion control reduces but cannot eliminate lead leaching from a lead pipe.

5. A — Bowl area = $0.785 \times 50^2 = 1{,}963$ sq ft. Volume per foot = $1{,}963 \times 7.48 = 14{,}685$ gallons/ft. At 3.0 ft/hr: $14{,}685 \times 3.0 = 44{,}055$ GPH (approximately 734 GPM). This calculation tells the operator how fast the zone is consuming water from storage during peak demand — essential for estimating how long the tank can sustain service.

6. C — A coagulant change alters finished water chemistry — pH, alkalinity, ionic balance, and residual metal concentrations may shift. These chemistry changes can destabilize iron deposits that have accumulated on pipe surfaces over decades. System-wide complaints confirm the change affected the entire distribution system, not just one local area. The previous iron deposits were in equilibrium with the old chemistry.

7. B — Atmospheric conditions in confined spaces can change at any time from biological activity, chemical reactions, utility intrusion, or weather changes. Each entry requires fresh atmospheric testing regardless of previous readings or how long the space has been open. OSHA requires pre-entry testing before every entry — an hour-old reading provides no guarantee of current conditions.

8. D — The PRV station is the hydraulic bottleneck — it cannot pass 2,200 GPM at its 55 psi setpoint. Installing a fire flow bypass (a parallel line with a normally closed valve that opens during high-demand events) would allow Zone 1's full 80 psi pressure to supplement Zone 2 during fire emergencies, dramatically increasing available fire flow.

9. C — A commercial bakery consuming zero gallons while operating normally means the meter has stopped registering flow. The AMI transmitter is working correctly (active status, strong signal) — it accurately reports the zero reading from the non-functioning meter. The measuring element has likely seized from age, debris, or mineral buildup. The bakery consumes water that goes unmeasured.

10. A — Pounds of chlorine = 3.8 × 2.0 × 8.34 = 63.4 lbs/day. Gallons of 12.5% solution = 63.4 ÷ (8.34 × 0.125) = 63.4 ÷ 1.043 = 60.8 gallons per day. Always calculate the pure chlorine requirement first using the pounds formula, then convert to the volume of chemical solution needed.

11. D — System pressure at the 12-inch main is 64 psi — adequate. The 39 psi pressure drop occurs within the 4-inch service line during the hospital's peak morning demand. High flow through the small service creates excessive friction loss. The service line is undersized for the hospital's current peak operations and should be upgraded to a larger diameter.

12. B — A persistent, growing wet area directly above a recorded 8-inch water main alignment — with no other visible source — is a classic indicator of a pressurized underground leak. The water migrates upward through the soil from the leaking pipe. Acoustic listening, leak correlation, or ground microphone surveys can confirm the leak location before excavation.

13. C — Recycled car wash water containing acid wheel cleaner, chemical detergents, road contaminants, and wax represents a high-hazard cross-connection. These chemicals could cause illness if they entered the drinking water through backflow. An RPZ assembly is the minimum acceptable protection. A single check valve provides essentially no reliable protection for this hazard level.

14. A — Original specific capacity: 400 ÷ 40 = 10.0 GPM/ft. Current: 400 ÷ (132 − 60) = 400 ÷ 72 = 5.6 GPM/ft. The 44% decline over 20 years indicates significant well deterioration — screen fouling, biofouling, or gravel pack degradation is restricting water flow into the well. Rehabilitation should be scheduled before the decline progresses to the point of pump damage.

15. D — PVC pipe is well-documented to be susceptible to permeation by chlorinated solvents like PCE. The solvent molecules dissolve into and diffuse through the PVC wall at the molecular level, entering the drinking water inside. With PCE above the MCL in the surrounding groundwater, customers could be exposed to a carcinogen. The pipe material must be changed to a permeation-resistant alternative.

16. B — A 7 psi decline in discharge pressure over six months at constant flow, constant amperage, and stable suction conditions is the classic signature of progressive wear ring and impeller deterioration. The widening internal clearances allow more water to recirculate from discharge to suction rather than being delivered to the system. The pump does the same work but with decreasing net output.

17. C — Chlorine and orthophosphate serve completely different functions that cannot be substituted for each other. Chlorine kills pathogenic microorganisms — protecting public health from waterborne disease. Orthophosphate forms a protective mineral film on pipe surfaces — preventing lead, copper, and iron from dissolving into the drinking water. Both chemicals are essential.

18. A — Cast iron and ductile iron pipes have different outside diameters for the same nominal size due to different historical manufacturing standards. A transition coupling accommodates both diameters with different-sized gaskets or adjustable glands on each end. Standard couplings designed for one material will not seal properly on the other.

19. D — A rising tank level with all pumps showing "off" indicates either a pump is running despite its SCADA status showing off (feedback failure), or water is flowing into the tank from a higher-pressure source through the distribution network. The operator must physically verify pump status at the station and investigate whether an interconnection or higher-elevation zone is feeding the tank.

20. B — The operator must immediately determine how much contaminated mixture (hypochlorite + fluoride) was fed into the system, what the resulting chemical concentrations were in the treated water, and whether customers were exposed to elevated chlorine levels. The contaminated tank must be drained and cleaned before the fluoride system returns to service.

21. D — The fertigation system creates both a chemical hazard (concentrated fertilizer) and a backpressure condition (injection pump operates above supply pressure). 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.

22. B — Zero chlorine residual at a normally-protected monitoring point means the water has no disinfection defense. The operator must flush immediately to restore residual, then investigate the cause — excessive water age, closed valve rerouting flow, main break, or treatment plant interruption. Waiting for bacteriological results before acting leaves customers drinking unprotected water.

23. C — At 70% output, the generator may not support all pumps simultaneously. The operator must triage — deciding which pumps are essential and which can be deferred. If the system needs more pumping capacity than 70% generator output can support, pressure will drop during the outage. This situation demonstrates why generator problems should be treated as urgent repairs.

24. A — Detention time = 300,000 ÷ 500 ÷ 60 = 10 hours. The tank turns over approximately 2.4 times per day — adequate for maintaining residual and limiting DBPs. However, actual mixing efficiency determines whether the theoretical turnover represents true replacement throughout the entire volume — short-circuiting can leave portions stagnant even at this theoretical rate.

25. D — The fire truck fill system's booster pump creates backpressure above supply, and fire trucks carry water potentially contaminated with foam concentrate, chemical runoff, petroleum products, and biological hazards from fire scenes. This combination of backpressure and high-hazard contamination requires an RPZ assembly or air gap.

26. B — At 4,000 GPM, every minute of delay wastes 4,000 gallons, further depletes the rapidly dropping tank, and increases the risk of system-wide pressure loss. Closing the isolation valves is the most time-critical action — it stops the water loss, preserves storage, and stabilizes system pressure. Everything else (excavation, notification, repair) follows isolation.

27. A — Firm capacity = output with the largest pump out of service. With three identical 600 GPM pumps, removing one leaves two in parallel producing approximately 1,100-1,150 GPM (slightly less than 1,200 due to increased system head from higher combined flow). This ensures the system can meet demand even during a single-pump failure.

28. C — When an entrant reports symptoms (lightheadedness), immediate evacuation is required regardless of monitor readings. The monitor at the entry point may not reflect conditions where the entrant is working — atmospheric hazards can vary within a space due to pockets, poor ventilation, and proximity to contamination sources. The entrant's physical symptoms always override instrument readings.

29. D — Radioactive materials represent the highest possible hazard level in cross-connection control. An air gap provides absolute, fail-safe protection with no mechanical components that can malfunction. For the highest-hazard connections (radioactive, highly toxic chemicals), an air gap is the only fully acceptable protection. Individual internal connections also need dedicated protection.

30. B — Static pressure = (880 − 795) × 0.433 = 85 × 0.433 = 36.8 psi. This is barely above the 35 psi minimum — and that's under static (zero demand) conditions. During any flow condition, friction losses reduce this already-marginal pressure further, explaining the measured 25 psi during peak demand. This customer is at the upper service elevation limit for this zone.

31. A — During a main break emergency, the buried valve cannot be operated. The operator must use more distant valves, isolating a larger area and affecting more of the 1,500 customers served by this section. The asphalt must be cut and the valve box raised to grade immediately — this is an emergency preparedness issue, not routine maintenance.

32. C — NRW = Production − Billed consumption = 4.5 − 3.4 = 1.1 MGD. Percentage = 1.1 ÷ 4.5 × 100 = 24.4%. This 1.1 MGD includes authorized unmetered use (0.15), apparent losses (0.35), and real losses (0.60). Understanding the composition helps prioritize corrective actions — leak detection for real losses and meter programs for apparent losses.

33. D — An alarm that triggers when the chlorine feed rate setpoint changes unexpectedly would notify the on-call operator within minutes of the cyberattack. While firewalls, encryption, and passwords are preventive measures, the alarm is the detection mechanism that catches an attack that has already penetrated the defenses. Early detection minimizes the duration of unchlorinated water entering the system.

34. B — An electromagnetic or ultrasonic inline inspection tool measures wall thickness from inside the pipe without excavation. The tool identifies areas of corrosion, pitting, and wall loss along the entire length. For a 1975-vintage steel main, this information reveals whether the pipe has adequate remaining wall thickness or whether targeted replacement is needed.

35. A — The 200 unprotected connections represent the most urgent risk — each is an unknown hazard that could contaminate the municipal supply at any time. The utility must survey these connections immediately, install appropriate devices, and establish annual testing. The 400 existing devices also require continued testing to verify ongoing function.

36. C — In severely corrosive soil (below 800 ohm-cm), polyethylene encasement alone may not provide sufficient protection because any tear or installation damage exposes the pipe to aggressive attack. Cathodic protection provides active electrochemical defense at these vulnerable points, protecting the pipe even where the encasement is compromised.

37. D — The imbalance could result from multiple causes: inconsistent rotation, SCADA programming favoring Pump 1, extended Pump 3 downtime, or historical hours before the policy was implemented. The operator must investigate all possibilities systematically. The overworked Pump 1 faces premature failure unless the cause is identified and corrected.

38. B — Blending the high-mineral well water with a lower-mineral source dilutes both contaminants below their SMCLs. If another well or purchased water is available with lower iron and manganese, adjusting the operating schedule to run both sources simultaneously can bring the blended levels below 0.3 mg/L iron and 0.05 mg/L manganese without installing treatment.

39. A — Q = 2,400 ÷ 448.8 = 5.347 cfs. D = 16/12 = 1.333 ft. A = 0.785 × 1.778 = 1.396 sq ft. V = 5.347 ÷ 1.396 = 3.83 fps, approximately 3.9 fps. This velocity is within the normal 2-5 fps range, confirming the 16-inch main is adequately sized for this flow rate.

40. C — A congested utility corridor with five existing utilities requires extreme care during excavation. Striking a gas line causes an explosion hazard. Cutting an electric line causes electrocution risk. Damaging a sewer line releases sewage contamination. The operator must hand-dig around all exposed utilities, maintain safe clearances, and protect each utility from damage during the water main installation.

41. C — Two systemic failures exist: an unresolved infrastructure problem causing 55 recurring low-pressure events, and alarm fatigue causing the operator to acknowledge without investigating. Both must be addressed — the physical cause of the pressure drops must be diagnosed and corrected, and the alarm response procedure must be reinforced with accountability for investigation.

42. A — The PRV reading 68 psi against a 55 psi setpoint indicates a mechanical failure preventing full pressure control. The spring may have weakened, the diaphragm deteriorated, debris may be on the seat preventing closure, or the pilot system may have malfunctioned. Without maintenance, the pressure will continue drifting higher, potentially damaging Zone 2 customer plumbing.

43. D — Compliance is based on the LRAA (0.072), which is below the 0.080 MCL — no violation has occurred. However, the single 0.088 result is a serious warning. Next quarter, the oldest result drops from the average and is replaced by the new result. If the new result is similarly high, the LRAA could exceed the MCL. Immediate operational action to reduce water age and DBPs is essential.

44. B — Per-minute rate = 1,680 ÷ 4 = 420 mL/min. Converting: 420 ÷ 3,785 = 0.111 GPM. Converting to GPH: 0.111 × 60 = 6.66 gallons per hour. Accurate chemical feed calibration ensures the intended dose reaches the water — under-delivery means inadequate treatment, and over-delivery wastes chemical and may create taste issues.

45. C — The slug of unchlorinated water is now moving through the distribution system. The operator must track its progress through residual monitoring, collect additional bacteriological samples to verify no pathogens entered during the gap, and be prepared to flush areas where residual drops below minimum levels. A 2-hour gap can affect water quality for much longer than 2 hours.

46. A — The piping between the pump station and Tank B has higher friction than the path to Tank A. During fill cycles, more water flows to Tank A through lower-resistance piping. During draw-down, Tank A supplies more demand through its easier flow path. Tank B receives and discharges less water, creating minimal cycling and the associated water quality problems.

47. D — Multiple factors compound: the corroded unlined cast iron surface consumes chlorine rapidly (high pipe wall demand), the dead-end configuration eliminates through-flow (maximum stagnation), the low C-factor produces low velocity (sediment settling and biofilm growth), and the combination creates the worst water quality in the system. Each factor reinforces the others.

48. B — Repair sleeve gaskets seal by compressing against the pipe's exterior surface. Any debris — dirt, corrosion scale, rough edges, or paint — beneath the gasket creates gaps that allow water to seep through under pressure. Thorough wire brush cleaning ensures a smooth, clean surface for the gasket to seal against.

49. A — The emergency plan relies on a resource that no longer exists. If an emergency requires the 800 GPM, operators will discover the interconnection is decommissioned only when they attempt to activate it — at the worst possible time. The plan must be updated immediately and alternative emergency supply arrangements identified to replace the lost 800 GPM.

50. C — Volume = $0.785 \times 40^2 \times 25 = 0.785 \times 1{,}600 \times 25 = 31{,}400$ cu ft. Weight = $31{,}400 \times 62.4 = 1{,}959{,}360$ lbs (approximately 980 tons). This enormous load must be supported by the tank structure and foundation. Engineers need this calculation for structural design and evaluation.

51. D — A single service connection provides zero redundancy for the most critical facility in the system. Any interruption — service line break, main failure, valve malfunction, or planned maintenance — completely eliminates water for patient care, sterilization, fire suppression, and dialysis. A second, independent service from a different main is essential for hospital water supply security.

52. B — HGL_A = $620 + (58 \times 2.31) = 754.0$ ft. HGL_B = $650 + (44 \times 2.31) = 751.6$ ft. Head loss = $754.0 - 751.6 = 2.4$ feet. The 30-foot elevation difference makes the simple 14 psi gauge pressure comparison misleading. HGL analysis incorporating both pressure and elevation reveals that only 2.4 feet of head is lost to friction in this 2,000-foot section.

53. C — An accidental spill mixing sodium hypochlorite with hydrofluosilicic acid could produce toxic chlorine gas. Chemical storage best practices require physical separation, individual secondary containment for each chemical, and clear labeling. These precautions prevent mixing from spills, delivery errors, or container failures that could create lethal atmospheric conditions.

54. A — Weekend demand is lower, so water moves through the system more slowly. Water reaching the monitoring point on Monday morning has been in the pipes through Saturday and Sunday — longer residence time allows more chlorine decay. When weekday demand increases on Monday, fresher water with higher residual moves through the system, and levels recover.

55. D — Without the elevated tank, the system has zero fire flow reserve. During the outage, the pump station must deliver fire flow instantaneously from its running capacity. If fire flow demand exceeds

pump capacity — or if a pump fails during a fire — there is no stored water to draw from. This is the most critical risk during the tank outage.

56. B — BTEX compounds and other petroleum hydrocarbons can permeate through PVC pipe walls at the molecular level. The contaminated soil from the leaking underground storage tank surrounds the pipe, providing a continuous source of hydrocarbons that slowly diffuse through the PVC into the drinking water. This is a well-documented limitation of PVC in contaminated environments.

57. C — The extra 6 turns during closure indicate debris on the valve seat preventing normal seating. The additional turns compressed through or displaced the obstruction. The 24-turn reopening count confirms the correct mechanical travel once the seat cleared. The valve should be flagged for potential cleaning during the next shutdown opportunity.

58. A — Annual cost = 0.85 MGD × 1,000,000 × $3.00/1,000 × 365 = $930,750/year. The $150,000 one-time survey investment identifies leaks whose repair saves nearly $1 million annually. Even finding and repairing only a portion of the leaks produces a dramatic return. This calculation is the strongest financial justification for proactive leak detection.

59. D — Chloramines are toxic to fish (destroying hemoglobin through gill membranes) and are not removed by standard dialysis carbon filters. Dialysis patients, fish/aquarium owners, and businesses dependent on free chlorine must all be notified with adequate lead time to modify their water treatment systems before chloraminated water reaches them.

60. B — Forcing deeper weekend cycling (e.g., 60-80% instead of 91-95%) exchanges more of the tank's stagnant volume with fresh supply. More turnover means less water age, higher residuals, and fewer DBP formation hours. Monday morning customers receive fresher water because the weekend cycling prevented the extreme stagnation that occurs with minimal cycling.

61. B — Eight consecutive years of declining fire flow — from 1,800 to 750 GPM — at the same hydrant clearly demonstrates progressive loss of carrying capacity. The unlined cast iron's internal tuberculation is steadily narrowing the effective diameter and increasing friction losses year over year. At 750 GPM, the area likely already fails minimum fire flow requirements.

62. D — To convert feet of head to psi: 9.4 × 0.433 = 4.07 psi, approximately 4.1 psi. This means the 2,500-foot section of 10-inch main carrying 1,000 GPM produces a modest 4.1 psi friction loss — demonstrating the excellent hydraulic performance of cement mortar lined pipe with C = 140.

63. A — Oxygen at 18.2% is below the OSHA minimum of 19.5% for safe entry. The space is oxygen-deficient, and entry is prohibited. The team must ventilate until oxygen exceeds 19.5%, identify what is consuming oxygen (likely biological activity from residual organic matter), and retest before entry. Air-purifying respirators are NOT acceptable for oxygen-deficient atmospheres.

64. C — The sprinkler system contains antifreeze (health hazard) and chemical corrosion inhibitors (health hazard), and the jockey pump creates backpressure above the municipal supply. This combination of chemical hazard plus backpressure is the textbook scenario requiring an RPZ assembly or air gap as the minimum acceptable protection.

65. B — Emergency interconnection valves that sit closed for years are subject to the same corrosion and seizing that affects all unexercised valves. Five years without operation virtually guarantees a seized valve. Including all emergency valves in the regular exercising program ensures they operate when the emergency demands it.

66. D — The distribution operator should monitor residuals closely, prepare for potential turbidity breakthrough into the distribution system, and be ready to flush affected areas. If the plant cannot maintain the 0.3 NTU limit, turbid water entering the system increases chlorine demand, deposits sediment, and may shield pathogens from disinfection.

67. A — Static pressure is measured with no water flowing — the system at rest. It represents the maximum available pressure from the storage tank's HGL minus elevation difference. Residual pressure is measured while water flows through test hydrants — representing how well the system maintains pressure under demand. The difference reveals the system's hydraulic reserve.

68. C — Repairing the 28 leaks saves 150 GPM × 525,600 min/year = 78.8 million gallons/year. At $3.50/1,000 gallons, annual savings = $275,940. The $60,000 investment produces a 4.6:1 return that continues every year. Eliminating a program that returns $4.60 per dollar invested to fund road paving is financially counterproductive.

69. B — The higher combined flow of 1,650 GPM increases friction in the common discharge piping compared to 950 GPM single-pump flow. This higher system head forces both pumps to higher-head, lower-flow operating points. The 150+ GPM shortfall is a normal characteristic of parallel operation that worsens with undersized common piping.

70. D — The dead-end main's severely tuberculated interior continuously generates iron particles from the corroded pipe surface. Flushing temporarily removes the discolored water, but the corroded surfaces immediately begin shedding particles again. The only permanent solution is cleaning and lining (to remove the corrosion and coat the surface) or complete main replacement.

71. C — Tank volume ÷ average daily demand = 400,000 ÷ 1,000,000 = 40%. AWWA recommends equalization storage of 25-50% of ADD. At 40%, the tank falls within this recommended range. However, total storage needs also include fire flow reserve and emergency reserve, which may require additional capacity.

72. A — The ±10 psi oscillation with a 15-second period around the 60 psi setpoint is classic PID instability. The proportional gain is too high, causing each correction to overshoot. Each overshoot triggers a correction in the opposite direction, sustaining the oscillation. Reducing proportional gain and tuning integral/derivative parameters will stabilize the output.

73. D — An operating well's cone of depression actively draws groundwater toward it. With a TCE plume 300 feet away, continued pumping could accelerate the plume's migration toward the well. Enhanced monitoring detects early arrival, environmental agency coordination ensures cleanup, and evaluation of offline status prevents drawing contamination toward the water supply.

74. B — Differential pressure = Discharge − Suction = 85 − 18 = 67 psi. The suction pressure (18 psi) represents energy already in the water before entering the pump. The pump adds 67 psi of energy. Converting to feet: 67 × 2.31 = 154.8 feet of total dynamic head.

75. C — PVC is non-metallic and non-conductive — standard electromagnetic locating equipment cannot detect it. Without tracer wire, the pipe is invisible to locators. Future excavators have no way to detect the main before digging, creating a serious risk of accidental pipe strikes.

76. A — High pressure at the bottom of a steep hill forces more air into solution (Henry's Law). When the customer opens their tap and pressure drops to atmospheric, dissolved air rapidly comes out of solution as microscopic bubbles. These bubbles create the milky appearance and rise to the top of a glass, clearing the water from the bottom up.

77. D — A progressive 2.5% monthly production increase over five months (totaling approximately 13%) with no new connections and declining seasonal demand points to a developing, growing leak.

The leak is slowly enlarging over time, consuming increasingly more water. A leak detection survey should be initiated before the leak progresses to catastrophic failure.

78. B — Q_available = 1,000 × [(58−20)/(58−40)]^0.54 = 1,000 × (38/18)^0.54 = 1,000 × 2.111^0.54 = 1,000 × 1.367 = approximately 1,367 GPM at 20 psi residual. This standard AWWA formula projects available fire flow from a single test measurement using the non-linear pressure-flow relationship.

79. C — A pump showing "running" but producing inadequate residual most likely has no chemical to deliver. The supply tank may be empty or the chemical may have degraded to the point where its available chlorine is negligible. Checking the tank level and chemical strength is the quickest first step that resolves the majority of these situations.

80. A — The production meter is the foundation for chemical dosing (pounds formula), water audit accuracy, demand projections, and regulatory reporting. A meter reading high causes overdosing and underestimates losses. A meter reading low causes underdosing and masks real losses. Annual calibration ensures this critical measurement remains accurate.

81. D — Elevated water temperature accelerates two harmful processes: chlorine residual decays faster at higher temperatures (reducing protection), and the TTHM/HAA5 formation reaction between chlorine and organic matter proceeds faster (increasing DBP levels). In chloraminated systems, warm temperatures also promote nitrification. Temperature management is a critical water quality consideration.

82. B — The pre-1960 unlined cast iron (22% of the system) generates 85% of failures. Targeting replacement investment on these worst-performing mains produces the maximum reduction in break rate per dollar invested. The remaining 78% of the system (post-1960 lined DI and PVC) generates only 15% of breaks and can continue serving reliably.

83. C — Standard four-gas monitors detect O_2, LEL, CO, and H_2S — but not chloramine, ammonia, or chlorine. A reservoir that normally stores chloramine-treated water will have residual chloramine on wet surfaces that can off-gas as the chamber dries. Chlorine-specific and ammonia-specific detectors are needed to evaluate this known, site-specific hazard.

84. A — The project specifications require restrained joints at all fittings. The contractor must comply with the specifications as written, regardless of whether the thrust block might also be adequate. The

design engineer specified restrained joints for reasons that may include soil conditions, water table concerns, or utility standards.

85. D — Project B affects the entire 12,000-connection system. If the main pump station's pumps fail, all customers lose water. The consequence of pump station failure dramatically exceeds the impact of the 30-home main break problem. Project A can be managed with reactive repairs while the highest-consequence risk is addressed first.

86. B — A comprehensive program prevents future events system-wide. Surveying all commercial/industrial connections identifies every hazard. Installing devices eliminates identified risks. Annual testing verifies device function. Enforcement ensures compliance. Public education builds awareness. These layered protections prevent contamination at any connection, not just the one that failed.

87. C — Pounds of chlorine = 6.0 × 2.2 × 8.34 = 110.1 lbs/day. Gallons of 12.5% solution = 110.1 ÷ (8.34 × 0.125) = 110.1 ÷ 1.043 = 105.6 gallons/day. Always calculate pure chlorine first using the pounds formula, then divide by the product of 8.34 and the solution strength to get gallons.

88. A — During a water quality emergency, all customers must receive and understand the health-critical notification. Customers with limited English proficiency who cannot understand the advisory cannot take protective action — they may continue drinking contaminated water. Bilingual communication through multiple channels ensures all community members are protected.

89. D — Combined chlorine = 2.5 − 0.3 = 2.2 mg/L. In a chloramine system, the 0.3 mg/L free chlorine suggests the chloramine is partially degrading, possibly from an improper chlorine-to-ammonia ratio. The released free chlorine can react with the remaining ammonia to form dichloramine and trichloramine — objectionable species that produce strong tastes and odors.

90. B — Static pressure of only 13.0 psi at zero demand — far below the 35 psi minimum — proves this customer cannot be served by this pressure zone. The 30-foot elevation difference between the tank overflow and the customer provides only 13 psi of gravity-fed pressure. No operational adjustment can increase this — the customer needs a higher tank, booster pump, or zone reassignment.

91. C — Pit depth (0.125") ÷ wall thickness (0.3125") × 100 = 40% of the wall consumed at the deepest pit. While 60% of the wall remains, the pit creates a stress concentration that weakens the wall

disproportionately. A structural engineer should evaluate whether the remaining thickness provides an adequate safety factor, and the tank needs interior recoating to halt further corrosion.

92. A — Safety training must precede all field work. Confined spaces, trench excavations, traffic hazards, electrical energy, and chemical exposure present lethal dangers to untrained workers. A single safety mistake on the first day can be fatal. Technical skills build over time, but safety knowledge protects the operator's life from day one.

93. D — For six months, the utility has been blind to conditions at three critical facilities. Alarms at these sites are not detected, pump failures not reported, tank levels unknown, and water quality changes not captured. Any emergency at these sites would be discovered only during a physical visit or customer complaint — potentially hours or days after the event began.

94. B — Annual cost = 720 kWh/MG × 3.5 MG/day × 365 days/year × $0.11/kWh = 720 × 3.5 × 365 × 0.11 = $101,124 per year. This calculation helps operators evaluate energy costs, justify pump rehabilitation (which reduces kWh/MG), and compare station efficiency against benchmarks.

95. C — Cutting, drilling, or tapping AC pipe releases asbestos fibers into the air. Inhaled asbestos fibers cause serious respiratory disease including mesothelioma and lung cancer. Wet-cutting techniques suppress airborne fibers, and appropriate respiratory protection (N100/P100 minimum) protects workers from inhaling any residual fibers.

96. A — Most distribution system water loss occurs through small, hidden underground leaks that never surface. These invisible leaks can run for years, wasting millions of gallons without any visible evidence above ground. Reactive response catches only the leaks that eventually surface or cause obvious damage — a fraction of the total losses in the system.

97. D — Six weeks without the elevated tank's buffer requires comprehensive preparation: verified backup power, pressure-based pump controls, fire department coordination, enhanced monitoring, pre-positioned repair materials, and adequate staffing for continuous operations. The system has zero margin for pump failure, power outage, or unusual demand during the outage.

98. B — The operator should validate the concern, explain the residual is safe, and offer practical solutions. Refrigerating water in a pitcher allows chlorine to dissipate naturally. A carbon pitcher filter effectively removes chlorine taste while the disinfectant continues protecting the water throughout the distribution system upstream of the customer's home.

99. C — 600 ÷ 16 = 37.5 hours at full load. With a 72-hour outage, the utility is 34.5 hours short. Arranging fuel delivery at 18-24 hours preserves approximately 14-20 hours of reserve for delivery delays caused by the winter storm. Proactive fuel management is essential — waiting until the tank is nearly empty leaves zero margin.

100. A — 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 responds faster to emergencies, plans better maintenance, makes smarter capital decisions, and provides better daily service. This knowledge comes only from decades of walking every street and touching every valve.