PRACTICE EXAM 6: WPI/ABC WATER DISTRIBUTION OPERATOR SIMULATION (100 QUESTIONS)

1. A distribution system operator is called to investigate a complaint of extremely low pressure at a commercial laundry that uses large volumes of water. The laundry is served by a 1inch service line connected to a 6inch main. System pressure at the nearest hydrant reads 58 psi. What is the most probable cause of the low pressure at the laundry?

A. The 6inch main is undersized for the demands of the commercial area

B. The 1inch service line is too small to deliver the high flow rates the laundry demands without excessive friction loss

C. The water meter at the laundry is clogged and restricting flow through the service

D. A pressure reducing valve upstream of the laundry has malfunctioned and is set too low

2. An operator samples the chlorine residual at four distribution system monitoring points and obtains these results: Site 1 = 1.8 mg/L, Site 2 = 0.9 mg/L, Site 3 = 0.4 mg/L, Site 4 = 0.05 mg/L. Site 1 is closest to the treatment plant and Site 4 is at the farthest dead end. What principle does this data illustrate?

A. Chlorine residual is not affected by distance from the treatment plant

B. The treatment plant is overdosing chlorine, as evidenced by the high reading at Site 1

C. All four sites meet the minimum residual requirement of 0.2 mg/L

D. Chlorine residual decays with increasing distance and water age, and Site 4 is essentially unprotected and requires corrective action

3. A pump station has three identical centrifugal pumps rated at 600 GPM each. During a peak demand event, all three pumps are running simultaneously. What is the firm capacity of this station?

A. Approximately 1,200 GPM — the output of two pumps operating in parallel, which represents the capacity with the largest pump out of service

B. Approximately 1,800 GPM — the output of all three pumps operating in parallel

C. Exactly 600 GPM — the output of a single pump operating at its rated capacity

D. Approximately 900 GPM — the average of one pump and two pumps combined

4. An operator is performing atmospheric testing before entering a belowgrade pump station wet well. The fourgas monitor reads: O_2 = 20.2%, LEL = 0%, CO = 2 ppm, H_2S = 8 ppm. The OSHA PEL for H_2S is 10 ppm. Should the operator enter?

A. No, because H_2S at 8 ppm indicates a dangerous atmosphere that will worsen once the space is disturbed

B. No, because oxygen at 20.2% is below the 20.9% normal level, indicating gas displacement

C. Entry is conditionally permitted because all readings are within OSHA limits, but continuous monitoring and ventilation must be maintained throughout the entry since H_2S is close to its PEL

D. Yes, without any special precautions because all readings are within acceptable limits

5. A newly installed 16inch ductile iron transmission main must be pressure tested before disinfection. The normal working pressure for this section is 85 psi. What is the minimum test pressure that should be applied?

A. 150 psi — because the test pressure is the greater of 150% of the working pressure (127.5 psi) or 150 psi

B. 127.5 psi — which is exactly 150% of the 85 psi working pressure

C. 85 psi — the test should match the normal working pressure to avoid stressing the pipe

D. 200 psi — all new transmission mains must be tested at 200 psi regardless of working pressure

6. A water utility has identified 15 locations in its distribution system where deadend mains consistently show zero or nearzero chlorine residual, elevated disinfection byproducts, and frequent customer taste and odor complaints. What single infrastructure improvement would most broadly address all three problems simultaneously?

A. Installing booster chlorination stations at each of the 15 deadend locations

B. Replacing all 15 deadend mains with larger diameter pipe to increase storage volume

C. Installing automated flushing devices at each dead end to periodically discharge stagnant water

D. Connecting the dead ends to adjacent mains to create loops, which would establish throughflow that reduces water age, maintains residual, and limits DBP formation

7. During an excavation for a main repair, the operator discovers that the existing pipe is wrapped in a deteriorated black material. Pulling back a section reveals the shiny surface of ductile iron pipe beneath. What is this wrapping material?

A. Cathodic protection tape that provides an impressed current to the pipe surface

B. Polyethylene encasement installed during original construction to protect against external corrosion from aggressive soil

C. A factoryapplied coal tar coating that has degraded over time

D. Electrical insulation wrap that prevents stray current corrosion

8. A water operator receives a complaint from a homeowner about a wet area in their front yard that never dries out, even during dry weather. The homeowner's water meter shows normal consumption. What should the operator investigate?

A. Whether the homeowner's irrigation system has a broken sprinkler head that is continuously leaking

B. Whether a sewer lateral beneath the yard has cracked and is leaking sewage

C. Whether the water main or service line beneath the yard has a slow leak that is saturating the soil from below, even though the leak may not be large enough to register on the customer's meter

D. Whether natural groundwater springs are surfacing in the homeowner's yard

9. An operator calculates the flow velocity in a 24inch main carrying 4,500 GPM. What is the approximate velocity?

A. 2.0 fps, which is below the recommended minimum for distribution mains

B. 5.1 fps, which is at the upper end of the normal operating range

C. 10.2 fps, which exceeds the maximum safe velocity for any operating condition

D. 3.2 fps, which is within the acceptable 25 fps range for normal distribution system operation

10. During a crossconnection control survey, an operator discovers that a restaurant has a carbonated beverage dispenser connected directly to the potable water supply. The dispenser introduces CO_2 gas into the water at pressures above the supply pressure to create carbonation. What type of backflow could occur at this connection?

A. Backpressure backflow, because the CO_2 injection pressurizes the beverage system above the supply pressure, which could push carbonated water and CO_2 back into the potable supply

B. Backsiphonage only, because beverage dispensers operate at lower pressure than the supply

C. No backflow risk exists because CO_2 is a foodgrade gas and is not considered a contaminant

D. Both backpressure and backsiphonage, requiring an air gap as the only acceptable protection

11. A water system treats 6.0 MGD. The current chlorine dose is 2.0 mg/L, and the operator needs to increase it to 2.8 mg/L to maintain adequate residual during a period of high demand. By how many additional pounds per day must the chlorine feed be increased?

A. 40.0 additional pounds per day based on the total new dose

B. 100.1 additional pounds per day based on the total feed at the higher dose

C. 40.0 additional pounds per day, calculated as 6.0 MGD × 0.8 mg/L increase × 8.34

D. 140.1 additional pounds per day based on the sum of the old and new doses

12. A distribution system experiences a series of main breaks during a cold snap when overnight temperatures drop to 5°F. Most of the breaks are circumferential fractures on cast iron mains. What is the primary mechanism causing these breaks?

A. The cold temperature makes the water inside the pipe freeze and expand, bursting the pipe from internal ice pressure

B. Frost penetration into the ground causes soil to heave and shift, applying bending stress to the brittle cast iron pipe, which fractures cleanly at the weakest point

C. Thermal contraction of the cast iron pipe creates tensile stress that exceeds the pipe's strength

D. Frozen service connections create backpressure that exceeds the main's rated pressure

13. A water utility's SCADA system generates an alarm indicating that the chlorine residual at a booster chlorination station has dropped to 0.0 mg/L. The booster station's sodium hypochlorite feed pump shows "running" status on SCADA. What should the operator investigate first?

A. Whether the sodium hypochlorite supply tank is empty — a pump running with no chemical to feed will produce zero residual despite showing an active status

B. Whether the SCADA chlorine analyzer has malfunctioned and is producing a false zero reading

C. Whether a large main break downstream has diluted the residual to undetectable levels

D. Whether the treatment plant has reduced the primary disinfectant dose entering the distribution system

14. A water system operates a well that produces water with naturally occurring arsenic at 0.008 mg/L. The MCL for arsenic is 0.010 mg/L. The system blends this well with a surface water source that has nondetect arsenic levels. What operational consideration is important?

A. The blending ratio must be maintained to keep the final arsenic concentration below the MCL

B. The arsenic level is so far below the MCL that no monitoring is necessary

C. The well must be shut down because any detectable arsenic level requires removal from service

D. Arsenic monitoring frequency can be reduced to once every ten years since levels are below the MCL

15. An operator inspects a groundlevel steel storage tank and discovers several areas on the interior floor where the coating has worn through and visible rust pits are forming in the bare steel. The deepest pit is approximately 1/16 inch deep. What is the appropriate response?

A. Ignore the pitting because 1/16 inch is insignificant relative to the tank wall thickness

B. Apply a temporary epoxy patch over each pit and schedule a full recoating during the next planned outage

C. Schedule the tank for draining, cleaning, surface preparation, and full interior recoating during the next available maintenance window — document the pit locations and depths for structural evaluation

D. Take the tank out of service immediately because any pitting indicates imminent structural failure

16. During a valve exercising program, an operator finds a valve that the GIS database shows as a 12inch gate valve, but the valve box opening reveals a butterfly valve operating nut. What should the operator do?

A. Record the valve as a gate valve per the GIS record since the database is the official reference

B. Document the actual valve type found in the field, record all operating characteristics, and submit a correction to update the GIS database with the verified field information

C. Assume the valve was replaced since the last GIS update and take no further action

D. Leave the valve unoperated since the operating procedure for a butterfly valve differs from a gate valve

17. A water system purchases finished water from a regional wholesale supplier through two interconnection points. The purchased water has a different pH (8.2) than the system's own wells (7.4). During periods when the system uses both sources simultaneously, what operational concern arises?

A. Blending water from different sources with different pH values can destabilize the corrosion control program, potentially disrupting the protective scale on pipes and releasing lead and copper into the water

B. The pH difference is too small to have any operational significance

C. The purchased water's higher pH will increase the effectiveness of chlorine disinfection throughout the system

D. The different pH values will cause visible discoloration where the two sources mix in the distribution system

18. An operator needs to calculate the daily chlorine requirement for a system that produces 2.5 MGD. The chlorine dose is 1.8 mg/L. The chemical on hand is 65% calcium hypochlorite. How many pounds of calcium hypochlorite are needed per day?

A. 37.5 pounds per day of calcium hypochlorite at 65% concentration

B. 24.4 pounds per day based on the available chlorine percentage times the system flow

C. 57.7 pounds per day — first calculating 37.5 pounds of pure chlorine needed, then dividing by 0.65 to account for the product strength

D. 120.4 pounds per day based on multiplying the pounds of pure chlorine by the concentration factor

19. A construction crew accidentally strikes and ruptures a 4inch gas line while excavating near a water main valve box. Natural gas is escaping and a strong odor is present. An operator had been preparing to exercise the water valve at this location. What should the operator do?

A. Continue the valve exercising work but avoid using any electrical tools near the gas leak

B. Move upwind 50 feet from the leak and wait for the gas to dissipate before resuming work

C. Use the water main valve to flood the area and suppress the gas leak

D. Evacuate the immediate area, move upwind and uphill, call 911, notify the gas utility, and do not operate any equipment or create any ignition source near the leak

20. A pump performance test reveals that a 5yearold centrifugal pump is delivering 1,050 GPM at 95 feet of head. The manufacturer's curve shows the pump should deliver 1,200 GPM at 95 feet. The motor amperage is normal. What is the most likely explanation for the reduced flow?

A. The pump suction strainer is partially clogged, restricting flow to the impeller

B. Wear ring deterioration is allowing approximately 150 GPM to recirculate internally from the discharge side back to the suction side rather than being delivered to the system

C. The discharge isolation valve is partially closed, throttling the pump output

D. The pump impeller has shifted position on the shaft, reducing its effectiveness

21. A water utility's annual water audit reveals that apparent losses account for 8% of total production. The utility has 18,000 water meters. What is the most effective strategy for reducing apparent losses?

A. Implement a systematic meter testing and replacement program targeting the oldest and highestthroughput meters, which are most likely to be underregistering

B. Conduct a leak detection survey to find and repair hidden distribution main leaks

C. Increase the chlorine dose at the treatment plant to compensate for losses

D. Install flow restrictors on all customer service lines to reduce maximum consumption

22. An operator is investigating why the discharge pressure on a vertical turbine well pump has declined 12 psi over the past year while the flow rate and motor amperage have remained stable. The pumping water level has also dropped 15 feet lower than last year. What is the most likely explanation?

A. The well screen has partially collapsed, restricting the flow of water into the well

B. The pump column has developed a crack that is allowing pressurized water to leak back into the well

C. The pump impeller has worn, reducing its efficiency and headproducing capability

D. The aquifer's water level has declined, increasing the pumping lift and consuming more of the pump's total dynamic head for lifting water, leaving less head available as discharge pressure

23. An operator is planning a unidirectional flushing program for a section of the distribution system served by a single 12inch trunk main with numerous 6inch and 8inch branch mains. In what order should the mains be flushed?

A. Flush the smallest mains first because they accumulate the most sediment per unit volume

B. Flush all mains simultaneously by opening all hydrants at once to maximize flow velocity

C. Flush the 12inch trunk main first starting from the supply source, then flush the branch mains in sequence from nearest to farthest from the trunk

D. Flush the branch mains first to push their sediment into the trunk main, then flush the trunk

24. An operator discovers during a routine inspection that the electrical panel at a pump station has a door hanging open. The panel houses the motor starters, VFDs, and control wiring for three pumps. Why must this panel door be kept closed and secured?

A. Open electrical panels allow excessive heat dissipation that causes VFD components to operate below optimal temperature

B. Open panel doors expose energized electrical components to moisture, dust, insects, and unauthorized contact — creating electrical shock hazards, equipment damage risk, and potential for arc flash events

C. Open panel doors create a tripping hazard for personnel walking through the pump station

D. The open door disrupts the electromagnetic shielding that protects SCADA communications

25. A water system's emergency generator at a critical pump station is tested monthly under load per the manufacturer's recommendation. During the November test, the generator starts normally but produces only 60% of its rated power output. The ambient temperature is 38°F. What should the operator do?

A. Run the generator under partial load for an additional 30 minutes to see if the output increases as the engine warms up fully

B. Record the reduced output as normal for coldweather conditions and retest in the spring

C. Replace the generator immediately because any output below 100% indicates a fatal mechanical failure

D. Schedule the generator for diagnostic service before winter — reduced output during actual emergencies could leave the pump station unable to maintain adequate pressure and flow

26. A distribution system has a large industrial customer that uses 400,000 gallons per day. The customer's facility has an internal fire sprinkler system, a cooling tower with chemical treatment, and a boiler with chemical additives — all connected to the potable water supply. How many separate backflow prevention assessments are needed for this facility?

A. At least three — each type of connection (sprinkler, cooling tower, boiler) represents a different hazard that must be individually assessed and protected with the appropriate device

B. One assessment covers the entire facility since a single RPZ at the main service entrance protects all internal connections

C. Two assessments — one for the fire sprinkler system and one combined assessment for the cooling tower and boiler

D. None, because the facility's large daily consumption ensures adequate forward flow that prevents backflow

27. An operator receives laboratory results for a quarterly DBP sample showing TTHM at 0.062 mg/L and HAA5 at 0.048 mg/L. The MCLs are 0.080 and 0.060 respectively. The LRAAs at this site are TTHM = 0.058 mg/L and HAA5 = 0.052 mg/L. How should the operator assess these results?

A. Both parameters are in compliance and no further attention is needed

B. Both parameters are in compliance based on the LRAAs, but the trends should be monitored since singlequarter results are creeping upward

C. Both parameters are in compliance based on the LRAAs, but operational measures to reduce water age at this monitoring site should be considered since values are trending toward the MCLs and a single high quarter could push the LRAA above the limit

D. The TTHM result exceeds the MCL and a public notification is required

28. An operator needs to calculate the volume of water in a standpipe that is 20 feet in diameter and has water at a depth of 95 feet. What is the approximate volume in gallons?

A. 14,139 gallons based on the circular area times the depth

B. 223,257 gallons, calculated as $0.785 \times 20^2 \times 95 = 29{,}845$ cu ft $\times$ 7.48

C. 148,200 gallons based on the diameter times the depth times 7.48

D. 29,845 gallons based on the cubic foot volume without converting to gallons

29. A water utility discovers that an employee has been acknowledging SCADA alarms without investigating them, creating a pattern where potentially serious conditions are being dismissed. During an audit, it is found that a lowtanklevel alarm was acknowledged but not investigated, and the tank subsequently dropped below its minimum level, causing a lowpressure event in the surrounding neighborhood. What systemic problem does this reveal?

A. The SCADA system is generating too many nuisance alarms, leading to alarm fatigue

B. The employee needs additional training on which alarms require investigation

C. The alarm setpoints are configured incorrectly and should be adjusted to reduce sensitivity

D. Multiple failures — alarm management procedures are inadequate, employee training may be insufficient, and supervision/accountability for alarm response is lacking — all of which must be addressed to prevent recurrence

30. An operator is evaluating the results of a water audit that shows the utility's nonrevenue water has increased from 18% to 26% over the past three years. Real losses increased by 5% and apparent losses increased by 3%. Which corrective actions should be prioritized?

A. Address both real losses (through leak detection and repair) and apparent losses (through meter testing and replacement) simultaneously, since both categories have contributed to the increase

B. Focus exclusively on apparent losses because they represent billing errors that are easier to fix

C. Focus exclusively on real losses because they represent physical water escaping the system

D. Take no action because 26% nonrevenue water is within the national average for utilities

31. A customer on a hilltop reports that their outdoor irrigation system does not function properly during summer afternoons — the sprinkler heads barely produce a mist rather than their normal spray pattern. Indoor plumbing works adequately but with noticeably reduced flow. The customer's neighbor at a lower elevation on the same street has no problems. What does this pattern indicate?

A. The customer's irrigation system has a clogged filter that needs to be cleaned

B. The customer's pressure regulator has failed and is restricting flow to the entire property

C. The customer is at the highest elevation in their pressure zone and during peak demand periods, the system pressure at their elevation drops below the minimum needed for proper sprinkler operation

D. The customer's water meter is undersized for the combined demand of indoor use and irrigation

32. A water system is developing a new Standard Operating Procedure for emergency main break response. The draft SOP lists the following steps in order: (1) Arrive at site, (2) Assess the break, (3) Begin excavation, (4) Close isolation valves, (5) Make the repair. What is wrong with this sequence?

A. The SOP should begin with a safety briefing before any field work is performed

B. The excavation step should come before the assessment step to save time

C. The repair step should include a postrepair pressure test that is missing from the list

D. Isolation valves must be closed BEFORE excavation begins — excavating an unisolated break is dangerous (workers are exposed to pressurized water, the break worsens, and the excavation floods) and wastes time

33. An operator is investigating a report of black particles in the water at several homes on the same street. The particles are soft, rubbery, and flake apart when squeezed. The homes are served by a 40yearold ductile iron main with deteriorating internal rubber gasket material at the joints. What is the likely source of the black particles?

A. Manganese dioxide deposits from the interior pipe wall that have broken loose

B. Degraded rubber gaskets from the pipe joints that have deteriorated over decades and are now shedding particles into the water flow

C. Biofilm that has grown on the pipe interior and sloughed off during a flow change

D. Deteriorated activated carbon from a wholehouse filter that one of the customers installed

34. A water operator must determine the pressure at the bottom of a storage tank that has 88 feet of water. The ground elevation at the tank is 720 feet. What is the pressure at the tank bottom?

A. 38.1 psi, calculated by multiplying 88 feet times 0.433 psi per foot

B. 311.5 psi, calculated by multiplying 720 feet times 0.433

C. 203.3 psi, calculated by multiplying 88 times 2.31

D. 350.1 psi, calculated by adding the ground elevation and the water depth then multiplying by 0.433

35. A distribution system operator discovers that a fire hydrant in a commercial district has been painted over by a property owner, covering the operating nut, nozzle caps, and nozzle threads with multiple layers of decorative paint. Why is this a serious concern?

A. The paint will accelerate corrosion of the hydrant body because decorative paint is not formulated for metal surfaces

B. The painted hydrant violates the utility's colorcoding system that communicates flow capacity to firefighters

C. The paint on the operating nut and nozzle threads may prevent or delay operation during a fire emergency, and the paint on the nozzle caps may prevent hose connection — potentially costing critical time during firefighting

D. The paint changes the hydrant's visibility rating under ISO fire protection standards

36. A pump station operator is troubleshooting a centrifugal pump that has suddenly lost all discharge pressure and flow. The motor is running, the suction valve is open, and the suction pressure gauge reads zero. What is the most likely condition?

A. The pump impeller has completely separated from the shaft and is no longer rotating

B. The pump has lost prime — air has entered the suction line or the supply source level has dropped below the suction pipe intake, and the pump is spinning but only moving air, which a centrifugal pump cannot pressurize

C. The discharge check valve has failed in the closed position, blocking all flow

D. The motor is running in reverse due to a phase reversal in the power supply

37. An operator conducts a hydrant flow test at a new commercial development. The static pressure is 52 psi and the residual pressure drops to 15 psi while flowing 800 GPM. The required fire flow for this development is 1,500 GPM at 20 psi residual. Based on these test results, can the system provide the required fire flow?

A. Yes, because the 800 GPM measured flow exceeds the fire department's typical pumper capacity

B. Yes, because the static pressure of 52 psi provides adequate reserve for additional flow

C. Additional calculations are needed, but the large pressure drop (37 psi) from only 800 GPM suggests the system likely cannot deliver 1,500 GPM at 20 psi residual

D. No, the system cannot provide the required fire flow — the residual pressure of 15 psi already falls below the 20 psi minimum at only 800 GPM, which means the system cannot even support the tested demand, let alone the required 1,500 GPM

38. A water system using chloramines for disinfection detects an unusual taste described as "fishy" or "medicinal" at several locations in the distribution system. Laboratory analysis confirms elevated levels of dichloramine and trichloramine. What operational condition causes the formation of these objectionable chloramine species?

A. An improper chlorinetoammonia ratio — if too much chlorine is fed relative to ammonia, the excess chlorine reacts with monochloramine to form dichloramine and trichloramine, which have strong, unpleasant tastes and odors

B. Excessive water velocity in the mains that converts monochloramine to its heavier molecular forms

C. Contamination of the ammonia supply with organic nitrogen compounds from the chemical supplier

D. Elevated water temperature that causes monochloramine to thermally decompose into its component species

39. An operator is reviewing a design for a new pump station and notices the engineer has specified a wet well with a very small volume relative to the pump capacity. The operator knows from experience that a small wet well causes pumps to cycle frequently. What operational problems does frequent pump cycling cause?

A. Frequent cycling improves pump efficiency by keeping the motor at optimal operating temperature

B. Frequent cycling extends pump life by preventing bearings from developing flat spots

C. Frequent cycling causes motor overheating, accelerated wear on starters and contactors, increased energy consumption from repeated inrush current, water hammer from flow transients, and pressure fluctuations for customers

D. Frequent cycling has no significant operational impact on modern pump systems with VFDs

40. A water utility receives a report that a residential customer's property has a strong sewage smell near their outdoor water meter pit. The operator opens the meter pit and finds it flooded with what appears to be sewage. The meter and connections are submerged. What is the immediate water quality concern?

A. The sewage will corrode the water meter and require replacement with a corrosionresistant model

B. The customer's water bill will be inaccurate because the submerged meter cannot register flow correctly

C. The meter pit flooding is an aesthetic nuisance but does not affect water quality

D. If distribution system pressure drops below the external pressure of the sewage surrounding the meter connections, contaminated sewage could be drawn into the potable supply through the meter fittings by backsiphonage

41. An operator discovers that the annual hydrant maintenance program has fallen behind schedule — only 60% of hydrants have been inspected and maintained this year. With winter approaching, which hydrants should be prioritized for the remaining maintenance?

A. Hydrants in commercial and highvalue property areas where insurance impacts are greatest

B. Dry barrel hydrants that have not been verified to drain properly, because standing water in unverified hydrants may freeze and render them inoperable during winter fires

C. Hydrants with the oldest paint that need cosmetic attention before winter visibility conditions

D. Hydrants closest to the pump station where pressures are highest and damage risk is greatest

42. An operator needs to calculate the pipe area of a 14inch main for a velocity calculation. What is the area in square feet?

A. 1.07 square feet — calculated as $0.785 \times (14/12)^2 = 0.785 \times (1.167)^2 = 0.785 \times 1.361$

B. 153.9 square feet — calculated using the diameter in inches without conversion

C. 0.785 square feet — calculated by using a diameter of 1.0 foot instead of converting correctly

D. 3.14 square feet — calculated using the full diameter squared times pi

43. A water operator is asked to explain why the utility applies both a corrosion inhibitor (orthophosphate) and a disinfectant (chlorine) to the treated water before distribution. A customer argues that the two chemicals are redundant. How should the operator respond?

A. The two chemicals serve the same purpose — both protect pipe material — and one could be eliminated

B. The chemicals are added at different concentrations and work at different points in the system

C. The two chemicals serve completely different functions — the disinfectant kills harmful microorganisms to protect public health, while the corrosion inhibitor forms a protective coating on pipe surfaces to prevent lead, copper, and iron from dissolving into the water — both are necessary

D. The corrosion inhibitor is optional and only added during winter months when corrosion rates are highest

44. A distribution system has a 500,000gallon elevated tank with a bowl diameter of 50 feet. The current water depth in the tank is 22 feet. SCADA shows the water level dropping at a rate of 3 feet per hour during the evening peak. At this rate, approximately how many hours of storage remain before the tank is empty?

A. Approximately 3.5 hours based on dividing the total tank volume by the hourly consumption rate

B. Approximately 11.0 hours based on the full tank depth divided by the drawdown rate

C. Approximately 5.0 hours based on the ratio of current depth to the fill rate

D. Approximately 7.3 hours based on dividing the current water depth by the drawdown rate

45. An operator inspects a well house and finds that the ventilation fan is not operating. The well uses a gas chlorination system with a 150pound chlorine cylinder connected to a wallmounted gas chlorinator. Why is ventilation critical in this space?

A. Ventilation prevents the chlorinator from overheating during highdemand periods

B. Chlorine gas is 2.5 times heavier than air and will collect at floor level if released — without ventilation, a small leak could build to dangerous concentrations that would incapacitate or kill anyone entering the space

C. Ventilation prevents condensation on the chlorine cylinder that would cause frosting

D. Ventilation is recommended but not critical because chlorine gas rises and will escape through the roof vent

46. A distribution operator reviews the daily SCADA report and notices that Pump Station A's total daily production was 2.1 million gallons, while the sum of all customer meter readings for that day (obtained from AMI data) was only 1.7 million gallons. Authorized unmetered uses (flushing, firefighting) for the day totaled approximately 50,000 gallons. What does the remaining discrepancy of approximately 350,000 gallons represent?

A. The 350,000 gallons represents a combination of real losses (leaks in the distribution system) and apparent losses (meter underregistration, data errors, and unauthorized consumption)

B. The discrepancy is caused by water expanding due to temperature changes in the mains during the day

C. The production meter at Pump Station A is overregistering and needs calibration

D. The AMI system missed readings from some meters and the discrepancy will resolve when all data is received

47. A water system's wellhead protection plan identifies an agricultural operation within the outer protection zone that applies anhydrous ammonia fertilizer annually. What specific contaminant does this agricultural activity threaten to introduce into the well's source water?

A. Lead, which leaches from fertilizer application equipment into the soil

B. Total trihalomethanes, which form when ammonia reacts with natural chlorine in the soil

C. Arsenic, which is a common impurity in anhydrous ammonia fertilizer products

D. Nitrate, which forms when ammonia in the soil is converted by bacteria through nitrification and leaches into groundwater — nitrate is a regulated contaminant with an MCL of 10 mg/L as nitrogen

48. During a main repair, the operator installs a fullcircle stainless steel repair clamp on a 6inch ductile iron pipe to seal a 3inch longitudinal crack. After tightening the clamp bolts, a small weep persists at one end of the clamp. What is the most likely cause and appropriate response?

A. The clamp gasket has a manufacturing defect and the clamp must be returned to the supplier

B. The pipe surface beneath the clamp was not properly cleaned of dirt and corrosion before installation

C. The weep is caused by debris or uneven pipe surface beneath the gasket preventing a complete seal — the operator should release the clamp, clean the pipe surface thoroughly, and reinstall

D. The crack extends beyond the length of the clamp and a longer sleeve is needed

49. A water utility is planning the replacement of 3,000 residential water meters as part of a systemwide AMI installation project. The existing meters are a mix of ages from 5 to 25 years old. In what order should the meters be replaced to maximize the benefit of the program?

A. Replace the newest meters first because they are easiest to remove and replace

B. Replace the oldest, highestthroughput meters first because they are most likely to be underregistering, meaning the utility recovers the most revenue soonest

C. Replace meters alphabetically by street name for administrative simplicity

D. Replace all meters in a single neighborhood at a time regardless of age for logistical efficiency

50. An operator is responding to a customer who is angry that their water was shut off without notice for a main break repair. The customer has a home dialysis patient who needs water for their treatment. What is the appropriate response?

A. Apologize sincerely, explain that the main break was an emergency that required immediate action, provide an estimated time for service restoration, help the customer identify alternative water sources for the dialysis treatment, and add this address to the critical customer notification list for future events

B. Explain that the utility has no obligation to provide notice for emergency shutoffs

C. Advise the customer to contact their insurance company for compensation

D. Tell the customer that main breaks are unpredictable and the utility cannot be held responsible

51. A 10yearold submersible well pump suddenly begins producing sand in the discharge water. The pump has operated normally for its entire service life until now. What is the most likely cause of the sand production?

A. The well screen has always been undersized, and the sand is just now becoming noticeable

B. The pump speed has increased due to an electrical supply change, pulling sand through the screen

C. The gravel pack around the well screen has settled, and surface sand is now bypassing the pack

D. The well screen has developed a hole, tear, or corroded opening that is allowing formation sand to bypass the screen and enter the pump intake

52. An operator is scheduling a comprehensive inspection of a 2milliongallon prestressed concrete groundlevel reservoir. The tank has been in service for 15 years and has never been taken offline for inspection. The operator has the option of using either a drainandenter inspection or an ROV (remotely operated vehicle) underwater inspection. What is the primary advantage of the ROV approach?

A. The ROV can collect water quality samples from different depths inside the tank

B. The ROV can make structural repairs while submerged, eliminating the need for a separate repair outage

C. The ROV inspection can be performed while the tank remains in service, avoiding the disruption of draining and the loss of storage capacity during the inspection period

D. The ROV provides more accurate structural measurements than visual inspection by divers or engineers

53. An operator calculates that a water system's average daily demand (ADD) is 4.2 MGD. The maximum day demand (MDD) recorded last year was 7.56 MGD, and the peak hour demand was 14.28 MGD. What are the peaking factors for MDD and peak hour?

A. MDD peaking factor is 1.8 and peak hour peaking factor is 3.4 — calculated by dividing each peak demand by the ADD

B. MDD peaking factor is 3.4 and peak hour peaking factor is 1.8 — the reverse of the actual calculation

C. MDD peaking factor is 7.56 and peak hour peaking factor is 14.28 — which are the raw demand numbers, not factors

D. MDD peaking factor is 0.56 and peak hour peaking factor is 0.29 — calculated by dividing ADD by each peak

54. A water system operates two elevated tanks — Tank A at the east end and Tank B at the west end of the service area. Both tanks serve the same pressure zone with open interconnections. The operator notices that Tank A consistently fills and drains 15 feet daily while Tank B cycles only 3 feet. What does this unequal cycling indicate?

A. Tank A is leaking and losing water faster than Tank B can supply through the interconnections

B. The system hydraulics route most of the flow through the eastern part of the system near Tank A, causing it to cycle more, while Tank B in a lowerdemand western area cycles less — resulting in higher water age in Tank B

C. Tank B's altitude valve is malfunctioning and restricting flow into and out of the tank

D. The two tanks have different overflow elevations and should not be interconnected

55. A water utility's operator discovers that the utility's crossconnection control program has not been actively enforced for the past two years due to staff vacancies. No surveys have been conducted, no new devices have been required, and annual testing of existing devices has not been tracked. What is the primary risk created by this lapse?

A. The utility's insurance premiums will increase due to the documented program deficiency

B. Customers with existing backflow devices will remove them since testing is not being enforced

C. The utility will lose its operating permit from the state regulatory agency

D. Backflow prevention devices that have not been tested annually may have failed without detection, and new crossconnections may have been created without the utility's knowledge — leaving the system vulnerable to contamination through unidentified or unprotected crossconnections

56. During a construction project, an inspector observes the contractor laying PVC pipe in a trench where the bedding material appears to be the native clay soil excavated from the trench. The project specifications require granular bedding. Why is native clay unacceptable as pipe bedding?

A. Clay expands when wet, creating excessive pressure on the pipe that can cause deflection or cracking

B. Clay bedding prevents future electronic locating of the pipe because clay blocks electromagnetic signals

C. Clay is not granular — it does not flow around the pipe to provide uniform support, it does not drain properly, and it can create point loads and uneven settlement that stress the pipe, particularly flexible PVC that depends on proper side support to maintain its shape

D. Clay bedding will chemically react with PVC pipe, degrading the pipe material over time

57. An operator receives a customer complaint about water that smells like "swimming pool chlorine" at a home located near the treatment plant's point of entry. The chlorine residual at the customer's tap measures 2.5 mg/L free chlorine. What is the appropriate response?

A. Acknowledge that the customer is close to the chlorine injection point where residual is highest, explain that the level is within the regulatory limit (maximum of 4.0 mg/L MRDL for free chlorine), and suggest running the tap or using a pitcher with a carbon filter to reduce the taste and odor

B. Reduce the chlorine dose at the treatment plant to eliminate the complaint

C. Issue a boil water advisory for customers near the plant because the chlorine level indicates a treatment malfunction

D. Advise the customer to stop drinking the water because any chlorine taste indicates an unsafe level

58. A water utility's budget analyst asks the distribution superintendent to justify the cost of the annual hydrant maintenance program. The program costs $45,000 per year for labor and materials to inspect, operate, lubricate, and paint 1,500 hydrants. What is the most compelling justification?

A. Hydrant maintenance prevents rust buildup that would make the hydrants look unsightly

B. Annual maintenance ensures that every hydrant operates when needed for firefighting, confirms drainage to prevent freezing, identifies needed repairs before emergencies, and provides data for fire flow planning — the cost is negligible compared to the potential consequences of hydrant failure during a fire

C. The program is required by the utility's contract with the fire department

D. Hydrant maintenance reduces the number of customer complaints about hydrant appearance

59. A water system operates a booster pump station that feeds a higherelevation pressure zone through a PRVcontrolled interconnection. The PRV failed during the night, and Zone 2 customers experienced pressures above 110 psi for approximately 6 hours before the failure was detected and corrected. What damage may have occurred?

A. No damage is likely because modern plumbing can withstand pressures up to 150 psi indefinitely

B. The excessive pressure may have triggered water heater pressure relief valve discharges at some homes

C. Only commercial customers would have been affected because residential plumbing is rated for higher pressures

D. Customer plumbing fixtures, water heater relief valves, toilet fill valves, and water supply connections may have failed or leaked, and existing small leaks in the zone's mains would have worsened — the utility should expect a spike in customer complaints and should proactively inspect for damage

60. An operator is calculating the head loss in a 3,000foot section of 12inch cement mortar lined ductile iron pipe (C = 140) carrying 1,800 GPM. After setting up the HazenWilliams calculation and obtaining a friction loss of approximately 14 feet, the operator converts this to psi. What is the approximate pressure drop?

A. 14 psi based on the head loss value equaling the pressure drop directly

B. 32.3 psi based on multiplying 14 feet by 2.31

C. 6.1 psi, calculated by multiplying 14 feet of head loss by 0.433 psi per foot

D. 1.9 psi based on dividing 14 by 7.48

61. An operator is explaining to a new hire why the utility records and tracks the number of turns required to close each gate valve during exercising. What is the practical reason for this information?

A. During an emergency main break, knowing the exact number of turns allows the operator to fully close the valve efficiently and confirm it is completely shut — and comparing the current count to the historical record can reveal internal problems such as a broken gate

B. The turn count is needed to calculate the valve's friction coefficient for hydraulic modeling

C. The turn count determines the torque setting for the valve key during exercising

D. The turn count is reported to the state regulatory agency as part of annual compliance documentation

62. A water system has a 750,000gallon elevated tank that serves as the primary pressure source for its zone. The tank is scheduled for interior recoating that will take 14 days. During this period, the pump station must maintain pressure without the tank's equalizing capacity. What is the most significant operational challenge during the tank outage?

A. Maintaining adequate chlorine residual without the mixing that occurs in the tank

B. Meeting peak hour demands that normally draw from tank storage to supplement pump output — without the tank, the pumps must have sufficient instantaneous capacity to meet peak demand directly

C. Preventing the pump station from overheating due to continuous operation

D. Maintaining adequate fire flow reserve without the tank's stored volume

63. A customer reports that their water has a bluegreen tint and a metallic taste. The customer's home was built in 2001 with copper plumbing. The system's corrosion control treatment maintains pH at 7.4 and adds orthophosphate at 1.2 mg/L. A firstdraw sample shows copper at 1.6 mg/L. What should the operator investigate?

A. Whether the customer's plumbing has unusually long runs of copper pipe with low demand

B. Whether the customer recently replumbed with new copper that has not yet developed a protective film

C. Whether the orthophosphate feed pump has been offline or malfunctioning, interrupting the corrosion control treatment

D. Whether the pH at the customer's location has dropped below the system target due to distance from the treatment plant, distribution system reactions, or blending with a different source — since a lower pH increases copper corrosivity

64. A distribution operator is preparing to make an emergency repair on a 16inch transmission main. The break is located 200 feet from the nearest accessible isolation valve. After closing the valve, the operator opens a hydrant downstream of the valve to drain the pipe before cutting. Why is this draining step important?

A. Draining the pipe section ensures that when the operator cuts into the pipe, residual pressure and trapped water do not create a hazardous surge, and it reduces the volume of water in the excavation that must be managed during the repair

B. Draining improves the quality of the pipe cut by ensuring the cutting tool operates on dry pipe

C. Draining the pipe prevents contamination of the repaired section during construction

D. Draining reduces the weight of the pipe section, making it easier to support during cutting

65. A water utility's AMI system detects reverse flow through a customer's meter for several hours each night between 2:00 AM and 4:00 AM. During the day, flow is normal (from the main toward the customer). What does this reverse flow pattern suggest?

A. The AMI transmitter is malfunctioning and reporting flow direction incorrectly during lowdemand hours

B. The customer's plumbing has a normal check valve that causes small backflow readings during pressure equalization

C. The customer may have a source of backpressure — such as a private well, booster pump, or thermal expansion system — that exceeds the distribution system pressure during the lowdemand overnight period when system pressure naturally drops slightly

D. The meter was installed backward and registers normal consumption as reverse flow

66. An operator discovers that a construction crew has stockpiled a large pile of fill dirt directly on top of a 24inch transmission main, creating an estimated 8 feet of additional load above the normal depth of cover. What is the concern?

A. The additional weight will increase the internal pressure in the main

B. The additional soil load may exceed the external load capacity of the pipe, causing deflection (for flexible pipe) or cracking (for rigid pipe), particularly if the pipe was not designed for the additional loading

C. The fill dirt will prevent the pipe from being located electronically in the future

D. The additional soil will insulate the pipe and cause the water temperature to increase

67. A water system completes a comprehensive leak detection survey and identifies 42 leaks across the distribution system — 35 on service connections and 7 on mains. The total estimated leak rate is 285 GPM. If all leaks are repaired, approximately how many gallons per day will be saved?

A. 285 gallons per day based on the instantaneous leak rate

B. 17,100 gallons per day based on one hour of the combined leak rate

C. 285,000 gallons per day based on multiplying the GPM rate by 1,000

D. 410,400 gallons per day, calculated by multiplying 285 GPM × 1,440 minutes per day

68. An operator is reviewing laboratory results and notices that a total coliform sample from monitoring site #7 was reported as "invalid — sample exceeded holding time." The sample was collected on Monday morning but did not arrive at the laboratory until Wednesday afternoon due to a courier error. What must the operator do?

A. Recollect the sample from the same monitoring site as soon as possible — the missed sample must be replaced to maintain the utility's compliance with its monitoring schedule

B. Count the invalid result as a negative (absent) since the extended time would have killed any bacteria

C. Reschedule the sample for the next regular monitoring period

D. Report the invalid sample to the state as a monitoring violation with no followup required

69. A water utility's emergency response plan includes a procedure for responding to a boil water advisory. The procedure lists the steps for issuing the advisory and lifting it. According to standard practice, what conditions must be met before a boil water advisory can be lifted?

A. System pressure must be restored above 35 psi for at least 4 hours

B. Two consecutive sets of satisfactory bacteriological samples (absent for total coliform and E. coli) must be collected at least 24 hours apart from the affected area, and system pressure must be restored to normal operating levels

C. The main break that caused the advisory must be fully repaired and inspected by a professional engineer

D. Twentyfour hours must elapse after the repair is complete, regardless of sampling results

70. A customer asks the distribution operator to explain their water bill. The bill shows consumption of 12 CCF for the month. The customer wants to know how many gallons that represents.

A. 120 gallons based on multiplying CCF by 10

B. 89.8 gallons based on multiplying CCF by 7.48

C. 8,976 gallons, calculated as 12 CCF × 100 cubic feet per CCF × 7.48 gallons per cubic foot

D. 1,200 gallons based on multiplying CCF by 100

71. A water system has a remote well site that is 15 miles from the nearest staffed facility. The well produces 800 GPM and operates under SCADA control. The SCADA communication link to the well has been lost for 4 hours. Attempts to reestablish communication have failed. What should the operator do?

A. Attempt to troubleshoot the communication link remotely using SCADA diagnostic tools

B. Contact the SCADA vendor for emergency technical support via phone

C. Wait until the next scheduled site visit to investigate the communication failure

D. Dispatch an operator to the well site to verify equipment status, check for alarms, verify water quality, inspect the communication equipment, and ensure the well is operating safely — the utility cannot allow a critical supply source to operate unmonitored for an extended period

72. An operator is evaluating the fire flow capacity at a hydrant that tested at a static pressure of 65 psi and residual pressure of 38 psi while flowing 1,000 GPM. The fire department requires 2,000 GPM at 20 psi residual. Using the relationship that pressure drop increases approximately with the square of the flow, would 2,000 GPM likely be available at 20 psi residual?

A. The pressure dropped 27 psi for 1,000 GPM. At 2,000 GPM, the drop would be approximately 4 times as much (108 psi), far exceeding the available 65 psi static — so 2,000 GPM at 20 psi is NOT available from this hydrant location

B. Yes, because doubling the flow only doubles the pressure drop, resulting in a residual of 11 psi

C. Yes, because the 65 psi static pressure provides adequate reserve for any fire flow demand

D. The calculation cannot be performed without knowing the pipe diameter and Cfactor

73. A water system is planning to replace its chlorine gas disinfection system with a sodium hypochlorite system. What is the primary reason utilities are making this transition?

A. Sodium hypochlorite is more effective at pathogen kill than chlorine gas

B. Sodium hypochlorite eliminates the significant safety risks associated with storing and handling pressurized toxic chlorine gas, including the need for SCBA, gas detection systems, RMP/PSM compliance, and emergency response capability

C. Sodium hypochlorite is less expensive per pound of available chlorine than chlorine gas

D. Sodium hypochlorite does not form disinfection byproducts unlike chlorine gas

74. An operator observes that the concrete surface pad around a well casing has a large crack running directly to the casing, and dirt and grass are growing in the crack. During the last rainstorm, water was observed flowing along the crack toward the casing. What corrective action is required?

A. Apply a temporary sealant over the crack and monitor during the next rainstorm

B. Install a gutter and downspout system to divert rainwater away from the pad

C. Repair or replace the concrete pad to restore a watertight, sloped surface that directs surface water away from the well casing — the crack provides a direct pathway for contaminated surface water to reach the annular seal

D. Raise the well casing stickup height to prevent surface water from reaching the casing opening

75. An operator is investigating a systemwide increase in customer complaints about reddishbrown water that began two weeks ago. The complaints come from all areas of the system, not just one neighborhood. No infrastructure work has been performed. What systemwide change could explain the broad pattern?

A. A major transmission main has developed internal tuberculation that is suddenly flaking off

B. The treatment plant has changed its source water or treatment process in a way that affects iron stability in the distribution system

C. All of the system's unlined cast iron mains have simultaneously begun to corrode at an accelerated rate

D. Systemwide brown water complaints that begin at a specific time and affect all areas typically indicate a change at the treatment plant — such as a new source water, a change in coagulant, a pH

adjustment, or a disruption of the corrosion control program — that has destabilized iron deposits throughout the entire distribution system

76. A confined space entry permit lists the maximum duration of the entry as 4 hours. After 3 hours and 45 minutes, the entrant is not finished with the inspection work. What should happen?

A. The entrant can continue for an additional 30 minutes since the work is almost complete

B. The entrant must exit the space, the entry permit must be closed, and a new permit must be issued with fresh atmospheric testing before reentering — permits have defined durations that cannot be extended without reevaluation

C. The attendant can extend the permit duration by annotating the original permit with the new end time

D. The entry supervisor can verbally authorize an extension without modifying the permit

77. An operator is asked to explain the purpose of an impeller wear ring in a centrifugal pump. What is the correct explanation?

A. The wear ring maintains a close clearance between the rotating impeller and the stationary casing to minimize internal recirculation from the highpressure discharge side back to the lowpressure suction side — and it is a replaceable component that wears preferentially to protect the more expensive impeller and casing

B. The wear ring seals the shaft penetration through the casing to prevent external leakage

C. The wear ring absorbs vibration from the impeller to protect the bearing housings

D. The wear ring is a sacrificial anode that protects the impeller from corrosion

78. A water system's emergency response plan specifies that during a major main break, the operator should "notify critical customers in the affected area." Which of the following would NOT typically be classified as a critical customer?

A. A hospital with emergency room and surgical services

B. A dialysis center that depends on municipal water for patient treatments

C. A nursing home with residents who have limited mobility and medical needs

D. A convenience store with a standard commercial water connection and no special waterdependent operations

79. An operator is conducting a pressure test on a newly installed 8inch PVC water main. After filling the main and venting all air, the operator pressurizes to the specified 200 psi test pressure. Over the next 2 hours, the pressure drops from 200 psi to 194 psi. The calculated allowable leakage for this section corresponds to a 7 psi drop. Does the main pass?

A. No, because any pressure drop indicates a leak that must be found and repaired

B. No, because PVC pipe should show zero pressure drop during testing due to its smooth joints

C. Yes, because the 6 psi drop is within the allowable leakage of 7 psi — the main passes the pressure test

D. The test is invalid because PVC pipe requires a different test protocol than ductile iron

80. An operator is investigating an area of the distribution system where several customers report that their water has an unusual sweet or fruity taste. The area is located adjacent to an industrial park. Testing shows the chlorine residual is normal, and bacteriological results are satisfactory. What type of contamination should the operator suspect?

A. Elevated manganese that is producing a sweet metallic taste

B. Volatile organic compounds (VOCs) from an industrial source that may be permeating through PVC service lines or entering the system through a crossconnection — certain solvents and industrial chemicals produce sweet or fruity tastes at very low concentrations

C. Algae growth inside the distribution mains that produces organic taste compounds

D. Fluoride overfeed at the treatment plant that creates a sweet taste

81. A pump station's SCADA system includes a flow totalizer that accumulates the total volume of water pumped. The totalizer shows 3,568,000 gallons pumped over a 24hour period. The pump station supplies water to a single pressure zone with 4,200 service connections. What is the average consumption per connection per day?

A. 849 gallons per connection per day, calculated by dividing total production by the number of connections

B. 3,568 gallons per connection per day based on dividing the total by 1,000

C. 14.9 gallons per connection per day based on dividing by 240,000

D. 85 gallons per connection per day based on dividing by 42,000

82. A water system uses two treatment chemicals: chlorine for disinfection and caustic soda (sodium hydroxide) for pH adjustment. The chemicals are stored in the same room. A new operator asks whether this storage arrangement is safe. What is the correct answer?

A. The arrangement is safe because both chemicals are used in water treatment and are compatible

B. The arrangement is unsafe because chlorine reacts violently with caustic soda in concentrated form

C. The chemicals should be stored separately — while they do not react explosively, best practice requires separating all treatment chemicals to prevent accidental mixing, crosscontamination, and to comply with chemical storage separation requirements

D. The arrangement is safe only if the chemicals are stored on opposite sides of the room

83. An operator discovers that a customer has illegally tapped into the distribution main to supply water to a construction site without a meter or approved connection. The tap was made by drilling a hole in the main and inserting a threaded fitting. What are the concerns with this unauthorized connection?

A. The only concern is the revenue loss from unmetered water use

B. The unauthorized tap creates only a minor leak that will seal itself under pressure

C. The illegal connection may be a code violation but does not affect system operations

D. The unauthorized tap is an unprotected crossconnection that could allow contaminated water to enter the main, the tap was made without proper tools creating potential structural damage to the main, and the unmetered water use represents theft of service and lost revenue

84. A distribution system operator notices that water from a specific well has an increasing sulfur taste and odor that has been getting worse over the past month. The chlorine dose has not changed, but the chlorine demand at this well has increased from 1.2 mg/L to 2.8 mg/L over the same period. What does the increasing demand suggest?

A. The well pump is drawing water from a deeper aquifer zone with different mineral content

B. Hydrogen sulfide (H_2S) levels in the raw well water are increasing, which consumes chlorine rapidly and produces the characteristic rottenegg sulfur taste and odor — the source of the H_2S (possibly sulfatereducing bacteria in the well or a change in aquifer conditions) should be investigated

C. The chlorine chemical has degraded and is no longer effective at the stored concentration

D. The well's pH has decreased, making the chlorine less effective and allowing sulfur compounds to persist

85. An operator needs to determine how many gallons per minute a well pump must produce to supply the utility's average daily demand of 2.5 MGD, assuming the pump runs 20 hours per day. What is the required flow rate?

A. 2,083 GPM, calculated by converting 2.5 MGD to gallons, dividing by 20 hours, then dividing by 60 minutes per hour

B. 1,736 GPM based on dividing 2.5 MGD by 24 hours then converting to GPM

C. 3,472 GPM based on doubling the required flow to provide a safety factor

D. 694 GPM based on the standard conversion factor for 1 MGD

86. A water system's operator training program includes annual confined space refresher training. During the training, the instructor asks why nonentry rescue (using a tripod and retrieval line) is preferred over entry rescue. What is the correct explanation?

A. Nonentry rescue is faster and generates less paperwork than entry rescue

B. Nonentry rescue is required by federal law for all confined space entries without exception

C. Nonentry rescue does not require anyone to enter the hazardous atmosphere, eliminating the risk of rescuers becoming additional victims — entry rescue exposes rescuers to the same hazards that incapacitated the initial entrant

D. Nonentry rescue equipment is less expensive to purchase and maintain

87. An operator calculates that a cylindrical tank 35 feet in diameter and 28 feet deep has a volume of approximately how many gallons?

A. 26,922 gallons based on using an incorrect conversion factor

B. 101,240 gallons based on calculating the volume in cubic feet but using the wrong diameter

C. 67,320 gallons based on calculating the circumference instead of the area

D. 201,369 gallons — calculated as $0.785 \times 35^2 \times 28 = 26{,}922$ cu ft × 7.48 gal/cu ft

88. A water system receives notification from a state environmental agency that a dry cleaning facility located within the utility's wellhead protection area has reported a release of perchloroethylene (PCE), a volatile organic compound, from their facility. The dry cleaner is approximately 400 feet from the utility's production well. What action should the operator take regarding the well?

A. No action is needed until PCE is actually detected in the well water

B. Increase monitoring frequency at the well for VOCs including PCE, coordinate with the environmental agency on the remediation effort, and evaluate whether the well should be taken offline as a precautionary measure depending on the proximity and severity of the release

C. Immediately shut down the well permanently because any VOC release within 400 feet guarantees contamination

D. Increase the well's pumping rate to create a larger cone of depression that captures the plume before it reaches other wells

89. An operator is asked to explain the relationship between the total dynamic head (TDH) a pump must develop and the pump's energy consumption. If the TDH increases by 20% due to increased system demand, approximately how does the power consumption change?

A. Power consumption increases approximately proportionally — a 20% TDH increase produces approximately a 20% increase in power, because pump power is directly proportional to the product of flow and head

B. Power consumption increases by 44% because power varies with the square of the head

C. Power consumption increases by only 10% because half the additional head is recovered as kinetic energy

D. Power consumption decreases because the higher system head forces the pump to a lower flow point

90. A water utility's operator discovers that a section of 8inch PVC main installed 10 years ago is located only 3 feet from a petroleum pipeline. The petroleum pipeline has been there since before the water main was installed. Recent soil testing near the petroleum pipeline shows hydrocarbon contamination in the soil. What is the specific risk to the PVC water main?

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

B. The hydrocarbons will raise the temperature of the water inside the PVC pipe

C. The petroleum contamination poses no risk to PVC pipe because PVC is chemically inert

D. Petroleum hydrocarbons can permeate through PVC pipe walls, entering the drinking water and causing taste, odor, and potential health effects — PVC is known to be susceptible to permeation by certain organic compounds

91. An operator performs a routine inspection of a pump station and discovers that the check valve on Pump 1's discharge line is leaking — water flows backward through idle Pump 1 whenever Pump 2 is running. The backflow through Pump 1 is estimated at 50 GPM. Beyond the wasted energy, what operational problem does this create?

A. The 50 GPM backflow is too small to cause any operational concern

B. The reverse flow will damage Pump 2's motor by creating an opposing force on its impeller

C. The leaking check valve reduces the net output of the pump station — Pump 2 must pump an extra 50 GPM just to maintain system flow, and the wasted water recirculates through the idle pump rather than reaching customers

D. The backflow will contaminate the water supply by introducing air through the idle pump's packing

92. A customer reports that their water pressure has gradually decreased over the past two years. The customer's home is 30 years old with galvanized steel piping throughout. System pressure at the meter reads 60 psi, but pressure at the kitchen faucet is only 18 psi. What is the most likely cause of the pressure loss?

A. The distribution system pressure has gradually declined due to increased demand in the neighborhood

B. The galvanized steel piping inside the customer's home has severely corroded and tuberculated over 30 years, restricting flow and creating friction loss that consumes 42 psi between the meter and the kitchen — this is a customerside plumbing problem

C. The customer's water meter has a partial blockage that reduces pressure to the house

D. A PRV at the zone boundary has gradually reduced its setpoint over time

93. An operator is developing a training program for new distribution system operators. Which of the following topics should be included in the training BEFORE the new operator is allowed to work independently in the field?

A. Confined space entry procedures, excavation safety, traffic control, chemical handling, lockout/tagout, and emergency response — all safetycritical topics that protect the operator and the public from day one

B. Advanced hydraulic modeling using computer software

C. Budget preparation and capital improvement planning

D. Public speaking and media relations for responding to press inquiries

94. A water system's SCADA display shows that an elevated tank's water level has dropped from 85% to 40% in the past 3 hours, which is much faster than normal. All pumps are running, and pump discharge pressures are normal. No main breaks have been reported, and no flushing or fire department operations are known. What should the operator investigate?

A. Whether the SCADA level transmitter has malfunctioned and is showing a false reading

B. Whether a large unauthorized hydrant opening is occurring somewhere in the zone

C. Whether the treatment plant has reduced production, limiting the supply to the distribution system

D. All of the above — the rapid, unexplained drawdown could be caused by a sensor error, an unreported main break, unauthorized hydrant use, a stuckopen altitude valve, or a combination — systematic investigation is needed

95. A water system has been ordered by the state regulatory agency to optimize its corrosion control treatment after exceeding the lead action level at customer taps. The utility's current pH is 7.2 with no corrosion inhibitor. The engineer recommends raising the pH to 7.8 and adding orthophosphate at 1.0 mg/L. What is the potential unintended consequence of raising the pH?

A. The higher pH will improve chlorine disinfection effectiveness throughout the system

B. The higher pH will reduce customer complaints about chlorine taste and odor

C. The higher pH will reduce the effectiveness of free chlorine disinfection because a greater proportion of the chlorine will exist as the weaker hypochlorite ion (OCl^-) rather than the stronger hypochlorous acid (HOCl)

D. The higher pH will cause immediate precipitation of calcium carbonate in all customer plumbing

96. An operator is responding to a customer complaint about recurring brown water that affects only the hot water — the cold water is always clear. The operator has already confirmed that system water quality is normal. What should the operator advise the customer?

A. The brown color indicates that the distribution main has internal corrosion that only affects hot water taps

B. The problem is inside the customer's water heater — sediment has accumulated at the bottom of the tank, and the sacrificial anode rod may have corroded significantly, releasing rust into the hot water — the customer should have their water heater flushed and inspected by a plumber

C. The customer should file a claim with the utility for a new water heater

D. The customer should stop using hot water until the utility can investigate further

97. A water utility is preparing its annual capital improvement plan and must decide between two competing projects: (A) replacing 2,000 feet of 80yearold cast iron main with 12 breaks in the past 3 years, and (B) constructing a new 1milliongallon elevated storage tank to serve a growing area. Both projects cost approximately the same. How should the utility prioritize?

A. Project A should be prioritized because the frequently breaking main represents an immediate, ongoing threat to public health (contamination at each break), service reliability (repeated outages), customer satisfaction (repeated disruptions), and increasing emergency repair costs — while the storage tank serves a future need that can be addressed by interim operational measures

B. Project B should be prioritized because growth requires new infrastructure before existing infrastructure replacement

C. Both projects should be deferred until the next budget cycle to accumulate additional funding

D. The projects are equally important and should be completed simultaneously by splitting the available funding

98. A customer calls to report that they turned on their tap and heard a loud "pop" followed by a burst of air and water, then the water turned brown for about 30 seconds before clearing. The customer's home is at the high point on a deadend street. What most likely caused this sequence of events?

A. A water heater failure caused a pressure surge that pushed air through the plumbing

B. A crossconnection with a compressed air system in a nearby building

C. A pocket of air trapped at the high point in the deadend main was released when the customer opened their tap, followed by sediment disturbed by the turbulence — this is common at high points on deadend mains where air accumulates

D. The customer's service line has a leak that allows air to enter the line when the tap is closed

99. An operator is assessing the condition of distribution system valves as part of an asset management program. Out of 4,200 valves in the system, the exercising program has identified 380 valves that are either inoperable (120 valves) or difficult to operate (260 valves). What is the valve operability rate for this system?

A. 91%, calculated by subtracting only the completely inoperable valves from the total

B. 97%, calculated by subtracting only the most critical valves from the total

C. Approximately 91% overall operability (3,820 operable out of 4,200), or approximately 97% if only counting the 120 completely inoperable valves — but both the inoperable and difficulttooperate valves should be tracked and addressed, with the 120 inoperable valves prioritized for repair or replacement

D. 100%, because difficulttooperate valves still technically function

100. A water distribution system serves a community where a significant portion of the population speaks Spanish as their primary language. The utility issues a boil water advisory due to a main break that caused systemwide low pressure. The advisory is published only in English on the utility's website and through Englishlanguage media. What deficiency does this communication approach have?

A. The advisory should also be printed in the local newspaper for broader distribution

B. The advisory should also be issued in Spanish through Spanishlanguage media, bilingual doortodoor notification in affected neighborhoods, and bilingual social media posts — to ensure all community members receive and understand the healthcritical information needed to protect themselves

C. The Englishonly advisory is sufficient because all residents are expected to understand emergency communications in English

D. Translation is not required because boil water advisories are selfexplanatory and do not require languagespecific communication

Practice Exam 6: Answer Key and Explanations

1. B — With 58 psi at the hydrant on the 6-inch main, the system pressure is adequate. The problem is the 1-inch service line — when the laundry demands high flow rates, the small-diameter service creates enormous friction losses that drop the pressure at the building far below the available pressure at the main. Upsizing the service line to match the customer's demand would resolve the issue.

2. D — Chlorine residual decays as water travels through the distribution system — consumed by reactions with pipe surfaces, biofilm, sediment, and dissolved organic matter. Site 4 at 0.05 mg/L is essentially unprotected, falling well below the recommended minimum of 0.2 mg/L. This dead-end location needs flushing, increased dosing, or system improvements to reduce water age.

3. A — Firm capacity is the pumping capacity with the largest single pump out of service. With three identical 600 GPM pumps, removing one leaves two operating in parallel at approximately 1,200 GPM (slightly less due to increased system head). This ensures the system can meet demand even during a single-pump failure — the worst-case equipment scenario.

4. C — All readings are within OSHA permissible limits: O_2 at 20.2% is above 19.5%, LEL at 0% is below 10%, CO at 2 ppm is below 35 ppm PEL, and H_2S at 8 ppm is below 10 ppm PEL. However, H_2S at 80% of its PEL warrants heightened vigilance — continuous monitoring and ventilation are essential because conditions can change rapidly in confined spaces.

5. A — The standard pressure test is the greater of 150% of working pressure or 150 psi. At 85 psi working pressure, 150% equals 127.5 psi — which is less than 150 psi. Therefore, the minimum test pressure is 150 psi. This ensures the main can withstand pressures significantly above normal operating conditions, including surge events.

6. D — Looping addresses the root cause of all three problems — stagnation. Dead-end mains have no through-flow, which means water sits and ages. Connecting them to create loops establishes continuous

flow that reduces water age, maintains chlorine residual, limits the contact time that produces DBPs, and provides redundancy and improved pressure as additional benefits.

7. B — Polyethylene encasement is a loose-fitting plastic sleeve installed around ductile iron pipe during original construction to protect against external corrosion from aggressive soil. Over time, the polyethylene can deteriorate, tear from soil movement, or be damaged by rocks in the backfill — exposing the pipe to the corrosive soil it was intended to protect against.

8. C — A persistently wet area in a yard that never dries — even during dry weather and with normal meter readings — is a classic sign of a slow underground water main or service line leak. The leak may be too small to register on the meter or may be on the utility's side (between the main and the meter). Investigation should include acoustic listening and correlation on the nearby main and service.

9. D — Q = 4,500 ÷ 448.8 = 10.03 cfs. D = 24 ÷ 12 = 2.0 ft. A = 0.785 × 4.0 = 3.14 sq ft. V = 10.03 ÷ 3.14 = 3.19 fps, approximately 3.2 fps. This velocity falls within the acceptable 2–5 fps range for normal distribution system operation, confirming the 24-inch main is appropriately sized for this flow.

10. A — The CO_2 injection system pressurizes the beverage dispenser above the distribution system supply pressure. If the supply pressure drops below the carbonation pressure, the higher pressure in the dispenser would push carbonated water and dissolved CO_2 backward into the potable supply. This is a backpressure condition requiring an RPZ or air gap.

11. C — The additional chlorine needed = dose increase × flow × 8.34 = 0.8 mg/L × 6.0 MGD × 8.34 = 40.0 additional pounds per day. The operator only needs to calculate the increase — the amount of additional chemical required above the current feed rate — not the entire new feed amount.

12. B — Cast iron pipe is brittle and cannot flex to accommodate ground movement. Frost penetration causes soil to heave and shift as water in the soil freezes and expands. This ground movement applies bending stress to the rigid, brittle cast iron, which fractures cleanly in a circumferential break at its weakest point. Ductile iron, by contrast, bends before breaking.

13. A — A metering pump showing "running" status but producing zero residual most likely has no chemical to pump. The sodium hypochlorite supply tank may be empty — the pump runs dry, producing no chemical delivery. The operator should check the tank level first, as this is the simplest and most common cause of zero residual with a running pump.

14. D — Although 0.008 mg/L is below the MCL of 0.010 mg/L, the margin is small. The blending ratio with the non-detect surface water source must be maintained to keep the final concentration below the MCL. If the well operates alone without blending, the arsenic level would remain below the MCL, but operational changes that alter the blend could push levels closer to or above the limit.

15. C — Coating failure and active pitting on a steel storage tank require professional attention — surface preparation and full interior recoating during a planned maintenance outage. The pits should be documented (location, depth, dimensions) for structural evaluation to determine if wall thickness has been compromised. Ignoring pitting leads to progressive wall thinning and potential structural failure.

16. B — Field-verified information always takes precedence over database records when a discrepancy is found. The operator should document the actual valve type, size, operating characteristics, and condition found in the field, and submit a correction to update the GIS database. Accurate records are essential for emergency response and system management.

17. A — pH is a critical parameter for corrosion control. The protective scale on lead and copper surfaces forms under specific pH and alkalinity conditions. Blending two sources with different pH values changes the water chemistry at the blend point and throughout the system, potentially destabilizing the protective film and releasing lead and copper into the water.

18. C — First calculate pounds of pure chlorine: 2.5 MGD × 1.8 mg/L × 8.34 = 37.5 lbs/day of pure chlorine. Since calcium hypochlorite is only 65% available chlorine: 37.5 ÷ 0.65 = 57.7 lbs/day of calcium hypochlorite product. Always divide the required pure chemical amount by the product strength (as a decimal) to get the actual product quantity needed.

19. D — A ruptured gas line is an immediately dangerous situation — natural gas is highly flammable and explosive. The operator must evacuate the area, move upwind and uphill (gas may collect in low areas), call 911, and notify the gas utility. No equipment should be operated, no valves turned, and no ignition sources created near the leak. Personal safety takes absolute priority.

20. B — A 5-year-old pump delivering 150 GPM less than its rated output at the same head, with normal amperage, indicates internal recirculation through worn wear rings. The pump does the same work (same amperage) but a portion of the water recirculates internally rather than being delivered to the system. Wear ring replacement would restore the missing 150 GPM.

21. A — Apparent losses are primarily caused by meter under-registration, unauthorized connections, and billing data errors. The most effective strategy targets meter accuracy — systematically testing and replacing the oldest and highest-throughput meters that are most likely to have degraded accuracy. Leak detection addresses real losses, not apparent losses.

22. D — If the pumping water level has dropped 15 feet but the flow rate is unchanged, the pump must now lift water an additional 15 feet. This additional lift consumes 15 feet of head (approximately 6.5 psi) that was previously available as discharge pressure. The pump's total head output is unchanged — but more of it goes to lifting and less to discharge pressure.

23. C — Unidirectional flushing proceeds from clean water to dirty water. The trunk main is flushed first starting from the supply source, pushing its sediment out through the farthest hydrant. Then branch mains are flushed sequentially, starting with those closest to the now-clean trunk, so that each branch receives clean water from the trunk to push its sediment out.

24. B — An open electrical panel exposes energized busbars, wiring, contactors, and terminal blocks to moisture (which causes short circuits and corrosion), dust (which insulates components and causes overheating), insects (which cause short circuits), and accidental human contact (which causes electrocution). Arc flash hazards are particularly severe inside panelboards with exposed energized components.

25. D — A generator producing only 60% of rated output cannot reliably power the pump station at full capacity during an actual emergency. If a power outage occurs during peak demand when all pumps are needed, the generator cannot support the load. Diagnostic service should be scheduled before winter storm season to identify and correct the problem.

26. A — Each connection type presents a different hazard level and requires individual assessment. The fire sprinkler may need a DCVA (if no additives) or RPZ (if additives are used). The cooling tower with chemical treatment is high-hazard requiring an RPZ. The boiler with chemical additives is high-hazard requiring an RPZ. A single device at the service entrance may not address all internal hazards appropriately.

27. C — While the LRAAs are currently in compliance (TTHM at 0.058 and HAA5 at 0.052), both are trending upward — the most recent quarterly results (0.062 and 0.048) are higher than the averages. A single high quarter could push either LRAA above the MCL. Proactive operational measures to reduce water age at this site (flushing, storage optimization) can prevent a future violation.

28. B — D = 20 ft. Volume = 0.785 × (20)² × 95 = 0.785 × 400 × 95 = 29,830 cubic feet. Gallons = 29,830 × 7.48 = 223,128 gallons, approximately 223,257 gallons with full precision. This is a large standpipe — the narrow diameter (20 ft) but tall water column (95 ft) provides significant pressure head.

29. D — This incident reveals multiple systemic failures: the alarm management system may be generating too many alarms (causing fatigue), the operator was not trained or supervised to understand that every alarm requires investigation, and no supervisory oversight or accountability system caught the pattern over three days. All three failures must be addressed — alarm rationalization, training, and supervision.

30. A — Both real losses (5% increase) and apparent losses (3% increase) contributed to the rise from 18% to 26% NRW. Addressing only one category leaves the other untreated. A combined approach — leak detection and repair for real losses, plus meter testing and replacement for apparent losses — provides the greatest total reduction.

31. C — The customer at the highest elevation receives the least pressure from the elevated tank. During peak demand, the HGL drops (tank level falls) and friction losses increase (higher flow in mains), both reducing available pressure. The highest-elevation customer is the first to feel these effects — their static pressure margin is already the smallest in the zone.

32. D — Excavating a break before isolating it is dangerous and counterproductive. Pressurized water will flood the excavation, endanger workers, undermine the trench walls, and the break will worsen as the pipe is exposed. Isolation valves must be closed first to stop the flow, then excavation can proceed safely in a controlled environment.

33. B — Soft, rubbery black particles that flake apart are characteristic of degraded rubber gasket material. In 40-year-old pipe, the rubber gaskets at push-on or mechanical joints can deteriorate from age, chemical exposure, and water contact, shedding particles into the flow. This is an infrastructure aging issue that ultimately requires joint rehabilitation or main replacement.

34. A — Pressure at the tank bottom = water depth × 0.433 = 88 × 0.433 = 38.1 psi. The ground elevation is irrelevant for calculating pressure inside the tank — only the height of the water column above the measurement point matters. The ground elevation would be used to calculate the HGL (720 + 88 = 808 feet) or the pressure at locations away from the tank.

35. C — Multiple layers of paint on the operating nut can prevent a hydrant wrench from engaging properly, delaying or preventing operation during a fire. Paint on nozzle threads prevents fire hose connections from seating. Paint on nozzle caps prevents removal. In a fire emergency, even seconds of delay can cost lives and property. The paint must be removed.

36. B — A centrifugal pump that has lost prime is spinning but only moving air — which it cannot pressurize. The zero suction pressure confirms that no water is reaching the pump. Causes include a drop in the supply source level below the suction pipe, an air leak in the suction line, or a closed suction valve. The pump must be stopped, the cause corrected, and the pump reprimed.

37. D — The residual pressure of 15 psi already falls below the 20 psi minimum with only 800 GPM flowing. The system cannot even support the tested demand at acceptable pressure, making it impossible to deliver the required 1,500 GPM at 20 psi. The area needs significant hydraulic improvements — larger mains, looping, or additional supply — before it can meet fire flow requirements.

38. A — Monochloramine (the desired disinfectant) forms when the chlorine-to-ammonia ratio is maintained at approximately 3:1 to 5:1 by weight. If excess chlorine is present (ratio too high), it reacts with the monochloramine to form dichloramine and trichloramine, which have strong, unpleasant "fishy" or "medicinal" tastes. Proper ratio control is essential for chloramine systems.

39. C — Frequent pump cycling generates excessive motor heat (startup current is 5–8 times running current), accelerates wear on electrical contactors, creates repeated water hammer events from flow transients, and causes pressure fluctuations that affect customers. The operator should recommend a larger wet well, VFDs to allow variable-speed operation, or smaller lag pumps to reduce cycling frequency.

40. D — A meter pit flooded with sewage creates a backsiphonage pathway. If distribution system pressure drops below the external pressure of the sewage surrounding the submerged meter connections (during a main break, high demand, or pump failure), contaminated sewage could be drawn into the potable supply. The pit must be drained, cleaned, and the source of sewage eliminated.

41. B — With winter approaching, the highest-priority hydrants are dry barrel units that have not been verified to drain properly. If these hydrants have standing water in their barrels, the water will freeze, potentially cracking the barrel and rendering the hydrant inoperable during a winter fire. Verifying drainage before freezing temperatures arrive is a critical safety priority.

42. A — D = 14 ÷ 12 = 1.167 feet. A = 0.785 × (1.167)² = 0.785 × 1.361 = 1.068 sq ft, approximately 1.07 square feet. Always convert diameter from inches to feet first, then apply the area formula A = 0.785 × D². Using the diameter in inches without conversion produces a drastically wrong result.

43. C — Disinfection and corrosion control serve completely different purposes. Chlorine kills pathogens — protecting public health from waterborne disease. Orthophosphate creates a protective mineral film on pipe surfaces — preventing lead, copper, and iron from dissolving into the water. Both chemicals are essential, and neither can substitute for the other.

44. D — At a draw-down rate of 3 feet per hour and a current depth of 22 feet: 22 ÷ 3 = 7.33 hours until the tank is empty. This calculation assumes the draw-down rate remains constant, which may not be the case — as the tank level drops, system pressure drops, potentially reducing demand. However, 7.3 hours is the planning estimate.

45. B — Chlorine gas is approximately 2.5 times heavier than air. In a room with a gas chlorination system, any leak causes chlorine to settle to floor level. Without continuous exhaust ventilation pulling air from floor level, a small, undetected leak can build to dangerous or lethal concentrations. The ventilation fan must be repaired immediately before the space is occupied.

46. A — The difference between production (2.1 MG) and the sum of metered consumption (1.7 MG) plus authorized unmetered use (0.05 MG) = 0.35 MG, or 350,000 gallons. This represents non-revenue water composed of real losses (leaks) and apparent losses (meter inaccuracy, unauthorized use, data errors) — both requiring investigation and corrective action.

47. D — Ammonia-based fertilizer applied to soil converts to nitrate through biological nitrification. Nitrate is highly mobile in soil and readily leaches into groundwater. The MCL for nitrate is 10 mg/L (as nitrogen), and elevated nitrate poses particular risk to infants (blue baby syndrome). Agricultural activity within the wellhead protection area is a primary source of nitrate contamination.

48. C — A persistent weep after clamp installation most commonly indicates that the pipe surface was not adequately cleaned before the clamp was installed. Dirt, corrosion scale, or tuberculation beneath the gasket prevents uniform contact, creating a pathway for water to seep past the seal. Releasing the clamp, cleaning the pipe thoroughly with a wire brush, and reinstalling typically resolves the leak.

49. B — Replacing the oldest, highest-throughput meters first targets the meters most likely to be significantly under-registering. These meters have processed the most water and experienced the most

mechanical wear, meaning they provide the greatest revenue recovery per replacement. This approach maximizes the program's financial return from the earliest installations.

50. A — The operator should respond with empathy and action: sincerely apologize for the unnotified interruption, explain the emergency nature of the main break, provide a realistic estimate for service restoration, actively help identify alternative water sources for the dialysis patient (bottled water, nearby facility), and immediately add this address to the critical customer list for future notifications.

51. D — A submersible pump that has operated sand-free for 10 years and suddenly begins producing sand most likely has a well screen failure. Corrosion, fatigue, or physical damage has created an opening in the screen that allows formation sand to bypass the filtration system. The pump should be shut down to prevent sand from damaging the pump and contaminating the system, and the well should be inspected.

52. C — An ROV inspection can be performed with the tank in service — the underwater robot enters through a hatch or access point, inspects all submerged surfaces with cameras, and exits without draining the tank. This avoids the significant operational disruption of taking a 2-million-gallon tank offline, the cost of draining and refilling, and the lost storage capacity during the inspection period.

53. A — MDD peaking factor = 7.56 ÷ 4.2 = 1.8. Peak hour peaking factor = 14.28 ÷ 4.2 = 3.4. These factors define the system's design requirements: pumps and storage must handle 1.8 times the average for maximum day conditions, and storage must supplement pumps to meet 3.4 times the average during the peak hour.

54. B — Unequal tank cycling indicates unequal demand distribution. Tank A's larger cycling means more water flows through the eastern service area, keeping water fresh. Tank B's minimal cycling means most of its stored water remains stagnant for extended periods, producing high water age, low residual, and elevated DBPs — all water quality problems concentrated near Tank B.

55. D — Two years without surveys means new cross-connections (from renovations, new equipment, new businesses) may exist without the utility's knowledge. Two years without annual testing means existing backflow prevention devices may have failed — check valves stuck open, relief valves non-functional — without anyone knowing. The system is operating with unknown and unverified contamination risk.

56. C — PVC is a flexible pipe that depends on proper side support from the surrounding bedding material to maintain its round shape under load. Clay does not flow around the pipe to fill the haunch area, does not drain (trapping water that destabilizes the trench), and can create point loads. Without proper granular bedding, PVC pipe deflects (goes out-of-round), which reduces capacity and can eventually cause failure.

57. A — A chlorine residual of 2.5 mg/L is within the EPA's maximum residual disinfectant level (MRDL) of 4.0 mg/L for free chlorine. The operator should acknowledge the customer's concern, explain that the elevated residual is normal for customers near the treatment plant, and suggest practical solutions — running the tap briefly or using a pitcher filter with activated carbon to reduce the taste.

58. B — The $45,000 annual cost ensures that all 1,500 hydrants will operate when firefighters need them. The cost of a single house fire where a hydrant fails — in property damage, potential injury or death, and liability — far exceeds the entire annual maintenance budget. The program also identifies failing hydrants before emergencies and provides flow data for system planning.

59. D — Sustained pressure above 110 psi — nearly double the PRV's intended 55 psi setpoint — can cause widespread damage: water heater relief valves discharge (flooding), toilet fill valves fail, supply line connections burst, faucet cartridges leak, and existing small leaks in the distribution mains become larger. The utility should prepare for a surge in service calls and proactively inspect the affected area.

60. C — Head loss in feet is converted to pressure loss in psi by multiplying by 0.433: 14 feet × 0.433 = 6.1 psi. This means the 3,000-foot section of 12-inch main at 1,800 GPM flow causes a 6.1 psi pressure drop due to friction. Remember: feet to psi uses 0.433, psi to feet uses 2.31.

61. A — The turn count serves two critical purposes: during an emergency, it allows the operator to close the valve efficiently (knowing that 24 turns means fully closed eliminates guesswork), and comparing today's count to the historical record reveals internal problems — significantly fewer turns may indicate a broken gate, while significantly more turns may suggest debris on the seat.

62. B — Without the elevated tank, the pump station has no equalization storage to supplement its output during peak demand. If peak hour demand exceeds the pump station's maximum instantaneous capacity, pressure will drop because there is no stored water to make up the difference. The pumps must have enough capacity to meet peak demand directly — a much higher requirement than when a tank is available.

63. D — Blue-green tints and metallic taste with copper at 1.6 mg/L (above the 1.3 mg/L action level) indicate aggressive corrosion of the copper plumbing. The most likely cause in a treated system is a pH drop at the customer's location — either from distribution system reactions, blending with a different source, or a treatment plant upset — that makes the water more corrosive than the target chemistry.

64. A — Cutting into a pipe that still contains pressurized water is extremely dangerous — the pressurized water can blast outward through the cut, injuring the operator, flooding the excavation, and undermining the trench. Draining the isolated section through a downstream hydrant depressurizes the pipe and removes the water, allowing the operator to make a clean, safe cut.

65. C — Reverse flow through a meter during overnight hours — when system pressure typically drops slightly due to minimal pump output — suggests the customer has a pressure source that exceeds the distribution system pressure during that period. A private well, booster pump, or thermal expansion in a closed plumbing system (with no expansion tank) could create this backpressure condition.

66. B — The additional 8 feet of soil above the normal burial depth applies significant additional weight to the pipe. Flexible pipes (PVC, HDPE) may deflect beyond their allowable limit, and rigid pipes (cast iron, concrete) may crack from the excessive loading. The pipe was designed for a specific depth of cover — additional loading beyond the design parameters risks structural failure.

67. D — Total volume saved = 285 GPM × 1,440 minutes/day = 410,400 gallons per day. This is a dramatic volume — over 400,000 gallons daily — illustrating why proactive leak detection programs provide such significant returns. At typical water production costs, this represents substantial daily savings in treatment chemicals, pumping energy, and recovered revenue.

68. A — An invalid sample due to exceeded holding time must be recollected as soon as possible to maintain compliance with the monitoring schedule. The utility cannot count the invalid result as either positive or negative. Missing a scheduled monitoring event may constitute a monitoring violation that requires public notification. The courier process should also be reviewed to prevent recurrence.

69. B — Standard practice requires two consecutive satisfactory bacteriological sample sets (absent for total coliform and E. coli) collected at least 24 hours apart from the affected area, plus restoration of normal system pressure, before a boil water advisory can be lifted. This confirms that the contamination risk has been eliminated and the water is safe for consumption.

70. C — 12 CCF = 12 × 100 cubic feet = 1,200 cubic feet. Converting to gallons: 1,200 × 7.48 = 8,976 gallons. CCF (hundred cubic feet) is a standard billing unit — each CCF equals 748 gallons. Operators must be able to convert between billing units and gallons to answer customer questions and verify billing accuracy.

71. D — A critical supply source operating without SCADA monitoring for 4 hours — after failed attempts to restore communication — requires a physical site visit. The operator must verify that the well is operating correctly, check for alarms, verify water quality, inspect the communication equipment, and determine why the link failed. Operating blind at a major facility is an unacceptable risk.

72. A — The pressure dropped 27 psi for 1,000 GPM of flow. Head loss increases approximately with the square of the flow — doubling the flow quadruples the head loss: 27 × 4 = 108 psi. Starting from 65 psi static, a 108 psi drop would require negative pressure, which is physically impossible. Therefore, 2,000 GPM at 20 psi residual is far beyond this location's capacity.

73. B — The primary driver of the industry transition from gas to liquid chlorine is safety. Chlorine gas requires SCBA, gas detection systems, RMP/PSM compliance, emergency response plans, and specialized training — all of which are expensive and create significant liability. Sodium hypochlorite eliminates the toxic gas hazard entirely, dramatically simplifying safety requirements.

74. C — A cracked surface pad with a direct path to the casing creates a contamination pathway. Rainwater flowing along the crack carries bacteria, chemicals, and surface contaminants directly to the annular seal. The pad must be repaired or replaced to restore a continuous, watertight, sloped surface that directs all surface water away from the well casing.

75. D — System-wide brown water complaints that begin at a specific time and affect all areas point to a change at the treatment plant — not localized distribution system issues. Changes in source water, coagulant type or dose, pH adjustment, or corrosion control chemistry can destabilize iron deposits throughout the entire system simultaneously, releasing iron and causing widespread discoloration.

76. B — Confined space entry permits have defined durations that cannot be extended without re-evaluation. The entrant must exit, the permit must be closed, atmospheric conditions must be re-tested, and a new permit must be issued before re-entry. This ensures that conditions inside the space (which may have changed) are re-evaluated before workers return.

77. A — Wear rings maintain the precise clearance between the spinning impeller and the stationary casing. This clearance must be tight to minimize recirculation from the high-pressure discharge side back to the low-pressure suction side. Wear rings are designed to be sacrificial — they wear preferentially so that the much more expensive impeller and casing are protected.

78. D — Critical customers are facilities where a water service disruption or quality problem poses a heightened risk to vulnerable populations or essential services. A convenience store with standard operations does not serve a vulnerable population and can manage a temporary water interruption without significant health or safety consequences. Hospitals, dialysis centers, and nursing homes serve populations that depend on water for life-sustaining purposes.

79. C — The 6 psi pressure drop is within the calculated allowable leakage of 7 psi. Some pressure decline during testing is expected from gasket seating, slight air compression, pipe wall absorption, and thrust block curing. The main passes the test and can proceed to disinfection and bacteriological clearance.

80. B — Sweet or fruity tastes in water near an industrial area suggest volatile organic compound contamination. Certain solvents (such as perchloroethylene from dry cleaners or trichloroethylene from degreasing operations) can permeate through PVC pipe walls from contaminated soil or enter through cross-connections. VOC sampling and investigation of nearby industrial activities are warranted.

81. A — Average consumption per connection = 3,568,000 ÷ 4,200 = 849 gallons per connection per day. This metric helps operators evaluate demand trends, identify areas of unusual consumption, compare to regional benchmarks, and plan for future capacity needs.

82. C — While chlorine and caustic soda are both water treatment chemicals, best practice requires separating chemical storage to prevent accidental mixing, cross-contamination during deliveries, and to provide secondary containment appropriate to each chemical's properties. Chemical separation is a standard requirement in treatment facility design and safety programs.

83. D — The unauthorized tap creates multiple serious concerns: it is an unprotected cross-connection (no backflow prevention), the drilling may have damaged the main's structural integrity, the unapproved fitting may leak or fail, and the unmetered water use is theft. The connection must be removed, the main inspected for damage, and the responsible party held accountable.

84. B — Increasing chlorine demand combined with worsening sulfur taste/odor suggests rising hydrogen sulfide levels in the raw well water. H_2S reacts rapidly with chlorine, consuming it and producing the characteristic rotten-egg smell. The source could be sulfate-reducing bacteria in the well, changing aquifer conditions, or intrusion from a different geological formation.

85. A — Daily production = 2.5 MGD = 2,500,000 gallons. Operating hours = 20 hours = 1,200 minutes. Required flow rate = 2,500,000 ÷ 1,200 = 2,083 GPM. The pump must produce a higher instantaneous rate than the average daily rate because it operates fewer than 24 hours per day.

86. C — Non-entry rescue eliminates the single most dangerous aspect of confined space emergencies: rescuers entering the hazardous space. The tripod and retrieval line allow the entrant to be extracted without anyone entering the dangerous atmosphere. Entry rescue requires rescuers to don SCBA and enter the space — exposing them to the same hazards that incapacitated the original entrant.

87. D — Volume = $0.785 \times (35)^2 \times 28 = 0.785 \times 1{,}225 \times 28 = 26{,}901$ cubic feet. Gallons = $26{,}901 \times 7.48 = 201{,}219$ gallons, approximately 201,369 gallons with full precision. This is a medium-sized cylindrical tank suitable for ground-level storage or as the bowl of a large elevated tank.

88. B — A confirmed VOC release within 400 feet of a production well requires heightened vigilance — increased monitoring for the specific contaminant, coordination with the agency overseeing the cleanup, and evaluation of whether to temporarily take the well offline. Continuing to pump without increased monitoring risks drawing the contamination plume toward the well through the cone of depression.

89. A — Pump power is proportional to the product of flow rate and total dynamic head (Power = Q × H × specific weight / efficiency). If TDH increases 20% and flow remains constant, power consumption increases approximately 20%. This linear relationship holds for constant-speed pumps at a fixed operating point on the system curve.

90. D — PVC pipe is susceptible to permeation by petroleum hydrocarbons and certain organic solvents. These compounds can pass through the PVC pipe wall at the molecular level, entering the drinking water inside and causing taste, odor, and potential health effects at very low concentrations. This is a known and well-documented limitation of PVC in contaminated soil environments.

91. C — The leaking check valve on Pump 1 creates a parasitic flow path — 50 GPM of Pump 2's output flows backward through idle Pump 1 instead of reaching customers. Pump 2 must produce an

additional 50 GPM above the system demand just to maintain flow, wasting energy and reducing the station's effective net output.

92. B — The 42 psi pressure loss between the meter (60 psi) and the kitchen faucet (18 psi) occurs entirely within the customer's internal plumbing. Galvanized steel pipe corrodes severely over 30 years, developing internal tuberculation that drastically reduces the effective diameter and creates enormous friction losses. This is a customer-side plumbing problem, not a distribution system issue.

93. A — Safety training must come first. Before any new operator works independently, they must understand the life-threatening hazards they will encounter: trench cave-ins, confined space atmospheres, electrical energy, traffic, hazardous chemicals, and emergency situations. Technical skills build over time, but a single safety mistake can be fatal on the first day.

94. D — Rapid unexplained tank drawdown requires systematic investigation of all possible causes: sensor malfunction (verify with a field measurement), unreported main break (check for customer reports, pressure anomalies), unauthorized hydrant use (check field evidence), stuck-open altitude valve (verify valve position), increased demand (check flow data), or a combination. Rushing to a single conclusion risks missing the actual cause.

95. C — Raising pH from 7.2 to 7.8 shifts the chlorine equilibrium from predominantly HOCl (the strong disinfectant) toward more OCl^- (the weak form). At pH 7.2, approximately 67% of free chlorine exists as HOCl; at pH 7.8, only about 35% is HOCl. This trade-off between corrosion control (higher pH) and disinfection effectiveness (lower pH) must be managed carefully.

96. B — When only the hot water is discolored and the cold water is clear, the source is definitively inside the customer's water heater — not the distribution system. Sediment accumulates at the bottom of the tank, and the sacrificial anode rod corrodes over time, both contributing rust and particles to the hot water. A plumber should flush the tank and inspect the anode rod.

97. A — The frequently breaking main is an immediate, ongoing public health and service reliability problem — every break risks contamination, disrupts service, damages surrounding infrastructure, and costs emergency repair money. The storage tank serves a future growth need that can be managed through interim operational measures (pump scheduling, interconnections). Immediate risks take priority over future needs.

98. C — High points on dead-end mains naturally accumulate air — dissolved air comes out of solution at low pressure points, and air enters during repairs. When a customer at the high point opens their tap, the trapped air pocket releases with a burst, followed by sediment disturbed by the turbulence. An air release valve at this high point would prevent the recurring problem.

99. C — Total operability: 4,200 − 380 = 3,820 operable valves, or 3,820 ÷ 4,200 = 90.9%. If counting only completely inoperable: 4,200 − 120 = 4,080, or 97.1%. Both metrics are useful — the 120 inoperable valves are the highest priority for replacement, while the 260 difficult-to-operate valves should be scheduled for maintenance to prevent them from becoming fully inoperable.

100. B — A boil water advisory is a health-critical emergency communication. Failing to reach Spanish-speaking residents means a significant portion of the community cannot take protective action — they may continue drinking contaminated water because they don't understand the advisory. Bilingual communication through multiple channels ensures all community members are protected.