



National Food Safety Guidelines for Cantaloupe and Netted Melons

Appendix C: Preharvest Water and
Corrective Actions

Version 2.0
February 2026

TABLE OF CONTENTS

ABBREVIATIONS AND DEFINITIONS.....	3
INTRODUCTION	4
Ag Water Assessments	4
Figure 1. Steps to assessing microbial water quality	5
Agricultural Water Source Assessment	6
Groundwater	6
<i>Table 1. Wells/Groundwater assessment</i>	6
Corrective actions for groundwater	8
<i>Table 2. Instructions for disinfecting a well with chlorine</i>	9
Surface water	11
<i>Table 3. Surface water assessment</i>	11
Agricultural Water System	13
<i>Table 4. Irrigation systems and associated risk</i>	13
Agricultural water system assessment	14
<i>Table 5. Assessing irrigation water delivery systems</i>	14
Corrective actions for agricultural water systems	15
<i>Table 6. Potential issues related to ag water distribution systems</i>	15
Water Treatment	16
Considerations for Water Testing	16
<i>Table 7. Examples of sampling strategies for preharvest ag water quality management</i>	16
RESOURCES AND REFERENCES	20
<i>Appendix C.1: Conversion table for calculating the amount of (70%) calcium hypochlorite required to dose specific well volumes at 50 mg/L (ppm)</i>	21
<i>Appendix C.2: Conversion table for calculating the amount of (25%) chloride of lime (a.k.a. calcium hypochlorite) required to dose specific well volumes at 50 mg/L (ppm)</i>	22
<i>Appendix C.3: Conversion table for calculating the amount of (5.25%) sodium hypochlorite required to dose specific well volumes at 50 mg/L (ppm)</i>	23

ABBREVIATIONS AND DEFINITIONS

Terminology	Definitions
Agricultural water (as used in this document based on FDA FSMA PSR)	Water used for preparing crop sprays, and water used for growing) and in harvesting, packing, and holding activities (including water used for washing or cooling harvested netted melons.
Agricultural water systems	(i) A source of agricultural water, (ii) the water distribution system, (iii) any building or structure that is part of the water distribution system (such as a well house, pump station, or shed), (iv) and any equipment used for application of agricultural water to netted melons during growing, harvesting, packing, or holding activities.
Closed delivery system	A water conveyance system in which water is transported from the source to the point of use through sealed, pressurized, or fully enclosed infrastructure (e.g., buried pipelines, sealed tanks, drip lines).
Drip irrigation	Water is delivered directly to the root zone via buried drip lines or indirectly to the roots via surface drip lines.
Furrow irrigation	Water is channeled between raised plant beds and infiltrating into the soil horizontally and vertically.
Hydrogeological pathways	The route(s) groundwater takes through the soil and rocks in the Earth’s crust.
Known or reasonably foreseeable hazards	A biological hazard that is known to be, or has the potential to be, associated with the farm or the food.
Open delivery system	A water conveyance system in which water is transported through open channels, ditches, canals, reservoirs, or other uncovered infrastructure.
Overhead irrigation	Water is applied directly via emitters onto the crop and soil surface.

INTRODUCTION

This section is a supplement to section 6.5 of the National Food Safety Guidelines for Cantaloupe and Netted Melons (the Guidelines). This document provides supplemental information for best practices related to the agricultural (ag) water systems assessments (AWA), water sampling and testing methods, and corrective actions. This appendix aligns with FDA's 2024 Agricultural Water Final Rule by emphasizing assessment-based, risk-driven decision-making rather than reliance on numerical microbial criteria alone.

Ag Water Assessments

In general, the purpose of conducting an AWA is to investigate and assess the likelihood that biological or chemical hazards may contaminate your ag water system including water source, storage, conveyance, distribution system, and all water-system related equipment. When conducted routinely, AWAs increase the foundational knowledge of your water system and provide opportunities to identify and document inherent deficiencies within or surrounding the system as well as circumstantial or periodic hazards that pose a contamination risk. AWAs are required both:

- 1) as a preventive measure to be conducted on a routine basis, and
- 2) as a corrective action as part of investigative and troubleshooting activities such as when a credible observation of potential contamination is reported or microbial water quality test results exceed the acceptance criteria.

When assessing the hazards to an ag water system, focus on known or predicted circumstances that could potentially lead to contamination. Just because a hazard is present does not necessarily mean it will result in contamination; identifying the hazards may allow you to evaluate the potential risk of contamination related to the hazard and, when appropriate, apply or establish measures to reduce the contamination risk. When a hazard is identified, specific efforts to determine the variable and dynamic risk exposure to your operations may be necessary.

The steps below in Figure 1 are to be followed when assessing water quality for netted melon production.

Figure 1. Steps to assessing microbial water quality

<p>EVALUATE ELEMENTS OF YOUR AG WATER SYSTEM</p> <p>(AT THE BEGINNING OF YOUR GROWING SEASON)</p>	<ul style="list-style-type: none"> • The nature of the ag water source (as per Tables 1 and 3 below) • The extent of your control over the agricultural water source (as per Tables 1 and 3 below) • The degree of ground water and environmental intrusion protection of your water source • Use of adjacent and nearby land (as per Appendix A) • The likelihood of introduction of known or reasonably foreseeable hazards
<p>EVALUATE ELEMENTS OF YOUR AG WATER SYSTEM</p> <p>(AT THE BEGINNING OF YOUR GROWING SEASON)</p>	<ul style="list-style-type: none"> • Location and nature of water source(s) (surface vs groundwater, Tables 1 and 3) • Type of distribution system (open vs closed; mixed) • Degree of protection against contamination (adjacent land use; nearby and in-proximity hydrogeologic pathways) • Agricultural water uses and practices (foliar contact, furrow and drip irrigation) • Environmental and other factors and conditions (i.e., seasonal patterns of water quality; fertigation)
<p>WATER TESTING (IF INCLUDED IN YOUR OPERATION'S SOP)</p>	<ul style="list-style-type: none"> • Section 6.5 of the Guidelines provides information on how to sample and test agricultural water. • Below in this appendix you will find additional considerations for conducting water testing. • Appendix B provides general information about microbiological sampling and testing.

Ag water systems are a function of the source, storage, conveyance, distribution system, and all water system-related equipment. Each component of an ag water system that is within your control, and even those that are accessible but not in your control (e.g., irrigation canals; sub-surface road conduits; gates and turn-outs), must be evaluated to identify potential sources of contamination (i.e., from adjacent land use and public access intrusion) that may affect the quality of ag water used for netted melon production. The objective of an ag water assessment is for the microbial quality of the water to be adequate for how it will be used (e.g., irrigation, chemical applications, cleaning of food-contact surfaces, post-harvest use, etc.).

Agricultural Water Source Assessment

It is best to begin assessing your ag water system at the water source. Water source refers to the point from which water is extracted or accessed including municipal systems, wells, reservoirs, canals, rivers, lakes, and streams. For instance, research conducted in the Arizona canal system recommended testing irrigation water at least 950 meters upstream from the point-of-use versus sampling only at the point-of-use (Lothrop, 2015). When evaluating your ag water system source, you should identify the characteristics, conditions, and activities that may lead to the transfer of fecal contamination from point and non-point sources. In addition to assessing water system components currently in use, you should also assess all components such as abandoned wells and ancillary equipment that are not in use as these unused wells and equipment can potentially serve as conduits for surface and subsurface waters during flooding or heavy rain. All abandoned wells should be properly decommissioned and verified to be free from cross-connections to surface and subsurface waters across the potentially connected distribution nodes and sources. A well becomes “abandoned” or “permanently inactive” if it has not been used for one year, unless the owner can demonstrate an intent for future use.¹

Groundwater

When assessing your irrigation wells, you should focus on the condition of the well components (as identified in Table 1), how the well is functioning compared to the original installation, the effect of any subsequent modifications and repairs of the well components, and the condition of the area surrounding the well. You should check your well(s) on a regular basis and, if possible, have a licensed contractor with water system engineering or agricultural/commercial well design and management expertise inspect it at least every five years. Keep records of the inspection dates and any recommendations and repairs that were made. Many issues associated with component parts of a well are not visible to the naked or untrained eye. When addressing issues that compromise the integrity of the well or its components, it is highly recommended to consult with an experienced professional (e.g., a well and commercial pump-system engineer, hydrogeologist, etc.).

For groundwater sources such as wells, evaluate the following components as identified in Table 1 and in section 6.5.2 of the Guidelines.

Table 1. Wells/Groundwater assessment

Item	What to Check	Why It Matters	Potential Corrective Actions
Well casing	Listen for water running down inside; laterally push casing to check for movement.	Cracks or instability allow contaminated water to enter the well.	Repair or replace casing; install a liner; consult a licensed contractor.
Annular space	Ensure a minimum of 25 feet of sealing material between casing and bore hole.	Proper sealing prevents surface water infiltration in the bore hole: casing gap into groundwater.	Re-seal the annular space; consult a licensed contractor.

¹ CA Dept of Water Resources, Part III. [Destruction of Water Wells](#)

Item	What to Check	Why It Matters	Potential Corrective Actions
Well cap or seal	Check that the well is sealed; no holes, missing plugs, or leaking water.	Prevents entry of insects, debris, and surface water contamination.	Replace the missing or damaged cap; install sanitary well seal; consult a licensed contractor.
Well vent	Inspect a vent screen for cleanliness, tears, or holes; confirm it faces downward to minimize windborne particulate intrusion.	Protects against the entry of insects, debris, and rainfall.	Replace or repair vent screen or reorient the vent; consult a licensed contractor.
Check-valve²	Verify that valve is keeping the water flowing in one direction towards the point of transfer or use and preventing extended water pull-down and backflow.	Stops potentially contaminated water in the distribution system from flowing back into the zone of drawdown and extraction.	Replace faulty check-valve; install additional backflow prevention device; consult a licensed contractor.
Concrete well pad	Inspect for cracks.	Cracks can allow surface water to seep into the well.	Repair or replace pad; seal cracks with concrete patch; consult a licensed well contractor.
Well pump	Confirm proper function; check for corrosion.	Malfunction or corrosion can compromise water safety.	Service or replace pump; remove and treat corrosion; maintain protective coatings.

²Water Systems Council. Well components: Valves. Available at: [PowerPoint Presentation](#)

Item	What to Check	Why It Matters	Potential Corrective Actions
Surrounding cleanliness	Look for animal feces, debris, and other contaminants around the well.	Reduces risk of external contamination reaching groundwater or contaminating well-head ports and connections.	Remove contaminants, fence off area; establish clean buffer zone around wellhead for further evaluation.
Gradient / drainage	Check for standing water near well; ensure water drains away from and not toward the well.	Standing water or drainage toward the well increases contamination risk.	Re-grade the ground to slope away from well; install drainage systems by licensed well contractor.
Proximity to potential contaminants	Look for nearby sewers, septic systems, animal enclosures, cesspools, or manure piles.	Nearby contaminant sources can leach or seep into the well.	Relocate contamination sources if this is possible; install protective berms, diversions, or more substantial barriers.
Depth	<p>Confirm that well depth, screen placement, and historical performance align with expected aquifer protection. Shallow wells (<50 ft) are often at higher risk of contamination.³</p> <p>Determine the depth of screens or slotting in the casing for accessing water in the unsaturated zone above the primary aquifer.</p>	Depending on regional geology, greater depth provides more natural filtration and protection against microbial and chemical contaminants.	<p>Consult a licensed well contractor.</p> <p>Treat extracted water continually during seasonal periods when extraction from the vadose (unsaturated soil) zone is being applied for crop production.</p>

Corrective actions for groundwater

If the total coliform level in a well water sample is above corresponding acceptance criteria per the Guidelines (section 6.5.3), wells should be disinfected in order to reduce or eliminate the contamination. Follow the disinfection steps outlined in Table 2 and keep records of when, why, and how disinfection was done as well as corresponding microbiological tests to confirm successful treatment.

³ [Learn About Private Water Wells | US EPA](#)

Table 2. Instructions for disinfecting a well with chlorine.

Any USEPA approved treatment can be utilized. Chlorine is a widely used chemical water treatment, but other chemical, physical, and biological treatments are also available.

Steps	Detailed Disinfection Instructions	Step Summary
<p>1. Create disinfectant solution</p>	<p>Using food-grade chlorine, create a solution containing at least 50 mg/l (or ppm - parts per million) available chlorine and add it to the well.</p> <p>Tables A-F in Appendices C.1-C.3 lists quantities of various chloride compounds required to dose 100 feet of water-filled casing at 50 mg/l for diameters ranging from 2 to 24 inches. If bringing the well back into service quickly is desired (such as when wells have been repaired or when a pump has been repaired or replaced), the solution should contain at least 100 mg/l available chlorine. To obtain this concentration, double the amounts shown in corresponding table.</p>	<p>Use the appropriate table in Appendices C.1-C.3 to make a 50 ppm (mg/L) chlorine solution and add it to the well.</p>
<p>2. Prepare work area and review disinfection procedures</p>	<p>To prevent contamination of the well during disinfection, first clean the work area around the top of the well. Remove grease and mineral deposits from accessible parts of the well head and flush the outside surfaces with chlorine solution (1/2 cup of food- grade sodium or calcium hypochlorite in 5 gal of water). Turn off the pump. Remove the cap or the well plug on the rubber seal.</p> <p>There are many types of well caps and plugs. If you have questions, you should contact a licensed well driller. If you have a submersible pump, you may also want to contact a licensed well driller for advice on disinfection procedures. Wash the pump column, drop pipe, or anything inserted into the well with chlorine solution. Try to coat the sides of the casing as you pour.</p> <p>NOTE: To prevent later corrosion, thoroughly flush sensitive pump parts such as wiring with fresh water after disinfection process is completed.</p>	<p>Clean surrounding area & disinfect well head. Turn off the pump. Remove well cap. Wash sides of well casing, pump column, and anything inserted into the well with chlorine solution.</p>
<p>3. Start disinfection process</p>	<p>After it has been placed into position, turn the pump on and off several times so as to thoroughly mix the disinfectant with the water in the well. Repeat this procedure 3 – 5x at 1-hour intervals. Test for the presence of chlorine in well discharge with a residual chlorine test⁴; if chlorine is not detected, the disinfection process should be repeated.</p>	<p>Mix well water by turning pump on and off several times until discharge tests positive for residual chlorine. Repeat 3 – 5x at 1-hour intervals.</p>

Steps	Detailed Disinfection Instructions	Step Summary
4. Standing time	The well shall be allowed to stand without pumping for 24 hours.	Let pump/well rest for 24 hours.
5. Wastewater disposal	<p>The wastewater shall then be pumped to land and contained. Avoid all water conveyance features such as swales, ditches, canals, creeks, or streams. Do not allow overland flow to reach surface waters. Pump until presence of chlorine is not detectable. The absence of chlorine is best determined by testing for available chlorine residual.⁵</p> <p>NOTE: Heavily chlorinated water should not be discharged into any plumbing system that utilizes individual sewage disposal systems (septic tanks). Such strong disinfectants could neutralize the bacteria needed to stabilize the sewage and may also damage the soil adsorption system.</p>	Pump water to a safe waste location until chlorine is no longer detected.
6. Test water	<p>A water sample shall be taken and submitted to a certified laboratory for examination. For individual wells, technical advice regarding the water sample collection may be obtained from your local health departments or from the laboratories that will examine the sample.</p> <p>If no technical assistance is available, use the following procedure: Use a sterile sample bottle, preferably one provided by the laboratory, along with an agent (usually in tablet or powder form) to neutralize any remaining residual chlorine. Before sampling ensure that the sample bottle is properly labeled with location, date, and time of sampling. It is extremely important that nothing except the water to be analyzed comes in contact with the inside of the bottle or the cap; the water must not be allowed to flow over an object (such as the hands) and into the bottle while it is being filled. If the water is collected from a sample tap, first sterilize the tap and immediate metal connection by heat (handheld "kitchen torch/burner") or sponge swabbing thoroughly with 70% isopropyl alcohol, then turn on the tap and allow the water to flow for 2 or 3 minutes before collecting the sample. Do not rinse the sample bottle. The sample should be delivered to the laboratory as soon as possible and in no case more than 6 hours after its collection. During delivery, the sample should be kept as cool as possible (but not frozen).</p>	Take a water sample using sanitary techniques and submit it to a lab for testing.

Steps	Detailed Disinfection Instructions	Step Summary
<p>7. Repeat as necessary per test results</p>	<p>The sample should be tested for both chlorine and total coliform. If the laboratory analysis shows total coliforms are above 99 MPN/1 liter or 9.9 MPN/100 mL, the disinfection procedure should be repeated.</p> <p>Depending on the level of contamination, it may be necessary to use a higher concentration chlorine solution (several times that shown in Table A-F in Appendices C.1-C.3). The water should then be retested. If repeated attempts to disinfect the well are unsuccessful, a detailed investigation to determine the cause of the contamination should be undertaken.</p>	<p>If testing shows microbial levels are still above acceptable action levels, repeat the disinfection process.</p>

Surface water

When assessing surface water sources such as canals, laterals, and ditches, you should focus on the integrity of surrounding banks (i.e. levees, sides, dikes, etc.) including potential point source and non-point source contributions such as run-off, intentional discharges, or human, domesticated and wild animal intrusion (e.g. drainage into these systems). Inspect these water sources on a regular basis and keep records of the date of inspection and any observations and corrections you made. For surface water sources, evaluate the following components as identified in Table 3 and in section 6.5.2 of the Guidelines.

Table 3. Surface water assessment

Item	What to Check	Why It Matters	Potential Corrective Actions
<p>Animal hazards</p>	<p>Look for fecal deposits, burrowing, animal immersion, or animal carcasses in or near the water. Inspect for animal intrusion or fecal deposition on water body banks, sides of canals and laterals, gates and turnouts, and unfilled tertiary laterals and ditches between irrigation events.</p>	<p>Fecal matter is a source of many zoonotic and human-specific foodborne pathogens (e.g., pathogenic <i>E. coli</i>, <i>Salmonella</i>, viruses, parasites).</p>	<p>Remove feces/ carcasses/ debris promptly; install fencing or deterrents; monitor and inspect for all types of human and animal activity.</p>
<p>Contaminating water (rain/ flooding)</p>	<p>Check if water source is impacted by runoff, flooding, or stormwater inflow.</p>	<p>Excess rain/ floodwater can carry human pathogens and hazardous chemicals, often attached to sediments, into the source.</p>	<p>Divert runoff; install buffer zones; avoid use immediately after flood events and monitor based on the baseline evaluation of your water.</p>

Item	What to Check	Why It Matters	Potential Corrective Actions
Cleanliness	Inspect for debris, trash, or buildup of foreign materials in the water.	Trash and debris can be a vector attractant, harbor human pathogens, and interfere with irrigation systems.	Remove debris regularly; establish water cleaning/filtration practices.
Macro-algal growth	Observe water for algal blooms or excessive macro-algae.	Pathogenic bacteria are known to find harborage on macro-algae and can cross-seasonally persist on river and reservoir banks during dry periods. Excessive algae can clog irrigation, alter water chemistry, and indicate nutrient pollution.	Control nutrient input; use aeration; mechanically remove algae but well-separated in time from irrigation uses; consider approved chemical and/or ultrasonic treatment.
Nearby animal activities	Assess surrounding land for grazing, livestock, or wildlife near water edges.	Direct and indirect (aerial) deposition of fecal matter increases contamination risk.	Restrict animal access with fencing; establish exclusion zones; coordinate with neighbors.
Upstream activities	Evaluate upstream management practices (other ag activities, harvesting activities, etc.).	Disturbances upstream can release sediment, human pathogens into the water.	Communicate with upstream users; time irrigation after disturbances; monitor water post-activity.
High-risk source designation	Review preseason water assessment results to determine if source is "high-risk." Based on historical water test results and historical information on the water source.	High-risk sources may need more frequent monitoring (such as testing) and additional controls.	Increase testing frequency; implement corrective actions; treat water before irrigation.
Adjacent / nearby land use	Identify roads, compost/manure piles, sewage systems, or human activity (i.e. squatters and unhoused encampments) near the water.	Adjacent land use can contribute to contamination with human pathogens.	If possible, relocate contaminant sources; create vegetative buffer strips; enforce setback distances. Consult with regional and county services.

Agricultural Water System

Agricultural water is conveyed through an open or closed system, and some water systems may have both open and closed components. The risk of contamination varies based on exposure to hazards, and closed systems have typically less exposure than open systems.

- **Closed delivery system:** A water conveyance system in which water is transported from the source to the point of use through sealed, gravity-flow or pressurized, or fully enclosed infrastructure (e.g., buried pipelines, sealed tanks, drip lines). Because the water is presumptively not exposed to the external environment, the risk of extrinsic microbial contamination during transport is minimized.
- **Open delivery system:** A water conveyance system in which water is transported through open channels, ditches, canals, reservoirs, or other uncovered infrastructure. Since the water is exposed to the environment, it is more vulnerable to contamination from runoff, wildlife, dust, and other external sources.

Most netted melon crops in the U.S. are irrigated by drip or furrow systems. Although irrigation water from these types of system is not expected to contact netted melons, it frequently does. This contact often happens when developing netted melons have contact with the sides of the beds and edges of furrows, when water splashes from furrows, or when drip tape is damaged. Water may also contact netted melons when agricultural inputs such as pesticides and foliar fertilizers are applied. Pesticides and fertilizers are typically mixed/diluted with water and then directly applied to vines, blossoms, developing fruit, and melon surfaces as netting develops and matures. As described in Table 4, contamination risk varies based on the type of delivery system through which water is applied and when water is applied.

Contamination of irrigation systems can be minimized or prevented with proper equipment maintenance and storage. You should inspect your irrigation water conveyance systems and equipment on a routine basis to ensure the condition of the equipment is not compromising microbial water quality. Document your inspections – both routine as well as in instances when microbial levels of irrigation water are above acceptable levels (e.g., for-cause sampling) as prescribed in the Guidelines (section 6.5.3).

Table 4. Irrigation systems and associated risk.

Steps	Definition	Risk profile & notes
Direct contact applications	Applies water directly via emitters onto the crop and soil surface.	Cantaloupe production systems are designed to minimize direct contact between irrigation water and developing fruit, particularly during flowering and pre-harvest periods. Any irrigation or water application practices that result in direct contact between water and the crop should be evaluated on a case-by-case basis, taking into account water quality, environmental conditions, and timing relative to harvest, as these factors influence the potential for pathogen survival and die-off.
Furrow	Water is channeled between raised plant beds and infiltrates into the soil horizontally and vertically.	Netted melons' exposure to irrigation water is reduced but not eliminated. Applied water crossing the raised bed at the head of the field or where a furrow blockage occurs (i.e. collapsed bed sidewall or tractor wheel soil mounding) or splashing of water or contaminated soil from furrows onto low-growing netted melons can still introduce human pathogens to the rind.

Steps	Definition	Risk profile & notes
Drip	Delivers water directly to the root zone via buried drip lines or indirectly to the root zone via surface drip lines.	This is considered the lowest-risk method, as it minimizes direct contact between irrigation water and the rind. Contamination risk increases if lines are damaged resulting in water leaks, if water pools near produce, or if emitters are contaminated.

Agricultural water system assessment

Irrigation systems should be inspected before use at the beginning of the season and monitored routinely throughout the season. During the season, system components should be on a regular maintenance schedule (Table 5). Filters should be routinely replaced or refreshed. Systematically monitor lines for physical damage as drip systems can be damaged by insects, animals, and equipment and cause leaks. Drip lines should be flushed routinely to remove accumulated sediments and algae blocking perforations/emitter openings.

Table 5. Assessing irrigation water delivery systems

	What to assess	How to assess
All components	Storage areas for equipment and components	Inspect for visual evidence of: <ul style="list-style-type: none"> • Animal roosting or nesting • Exposure to compost or other farm inputs
	Irrigation system components	Protect from impact from sanitary unit/toilets maintenance and use.
Open delivery system	Irrigation ditches	Check for accumulation of sediments, residues, aquatic plants (moss), algae, and standing water.
Mechanical & conveyance components	Primary and secondary filtration equipment	Check for cleanliness and proper function.
	Seals, gaskets, and fittings	Check for leaks.
	Conveyance and components	Check for overall cleanliness (especially at the beginning of the season).
	Water lines	Check for visual evidence of microbial growth including, but not limited to, white stringy slime and red filamentous, thread-like sludge. ⁴

⁴ Shortridge J., Benham B. 2018, Filtration, Treatment, and Maintenance Considerations for Micro-Irrigation Systems, Virginia Cooperative Extension, Pub. No. 442-757. [Filtration-Treatment-and-Maintenance-Considerations-for-Micro-Irrigation-Systems.pdf](#)

What to assess		How to assess
Drip irrigation systems	Water lines	Check for physical damage and leaks.
	Filters	To prevent bacterial growth, inject chlorine upstream from filter units.

Corrective actions for agricultural water systems

If you have reason to question the microbial quality of your ag water distribution system (e.g., have a failed water test from your irrigation system) your goal is to, as quickly as possible, correct any issues that raised your concern. You will also need to determine if unharvested netted melons were exposed to water that was of questionable quality or was not adequately treated. It is best to conduct an assessment based on factors such as time until harvest and microbial quality of water when determining what do with crops which came into contact with ag water that was inadequately treated or of questionable quality. It is important to record all corrective actions taken.

Table 6. Potential issues related to ag water distribution systems

Issues	Preventative maintenance & corrective action guidance
Cross-connections in the conveyance system.	Make sure that your conveyance, holding, and distribution system is not connected to another source of water that may be contaminated (e.g. a defunct agricultural or community water system; minimal acre-feet ordered irrigation district excess water diversion backflow).
Inadequate back-flow protection.	Install back-flow prevention devices (available at most hardware and plumbing supply stores).
Dead-end or unused water lines connected to your distribution system.	Flush lines regularly or remove any used lines or sections of the water system.
Abandoned or inactive wells on my property.	When no longer in use, wells must be decommissioned to prevent them from functioning as a vertical conduit for contaminants that could impact the entire water supply. The process of decommissioning, capping or sealing an abandoned or inactive well must be done by carefully filling the interior of the well casing with a sealing agent. This procedure should be conducted by personnel with expertise in this type of activity.
Storage tanks	If water in storage tank tests positive for generic <i>E. coli</i> , contact a trained individual to clean and disinfect the tank. Document all cleaning and sanitizing events.

Water Treatment

Important to all agriculture water treatment systems are the components that are put together to create a successful system capable of reducing microbiological indicator organisms to acceptable levels. There are typically three types of water treatment systems that a grower may employ to improve their water’s microbial quality: Liquid chemical injection systems, tablet systems, or physical treatment with a pesticide device. When treating your ag water with an antimicrobial agent, it is important to follow the manufacturer’s instructions to achieve and maintain the appropriate concentration throughout the system.

Sodium and calcium hypochlorite systems are popular because they are effective and readily available at a lower cost than most other treatments. The effectiveness of chlorine depends on the residual concentration, presence of organic matter, contact time, pH and temperature. Chlorine is optimally available for disinfection when the water pH is between 6.0 and 7.5 and water temperature > 20°C (WHO, 2017). To ensure that the treatment is effective throughout the entire irrigation network, chlorine residual should be verified not only at the point of injection but also at the farthest emitter or outlet. This confirms that the disinfectant concentration remains adequate across the full distribution system.

Considerations for Water Testing

Numerous factors need to be considered when sampling and testing ag water. Table 7 describes these factors when conducting testing for routine monitoring of the water’s microbial quality or for-cause (i.e., when investigating an abnormal test result or when there is an increased likelihood of contamination).

Table 7. Examples of sampling strategies for preharvest ag water quality management

Decision point	Recommended practice for:	
	Routine monitoring for total coliform in ground water or generic <i>E. coli</i> in surface water	For-cause sampling
Where to sample	Sample at the point of extraction and at the point of use (e.g., final sprinkler head or hose outlet that represent where the water actually contacts the crop).	Test water source and any network node connections (e.g. gates, mixing sumps, valves, risers) along the distribution system to the point of “for-cause” test result. (When indications of fecal contamination are elevated, use extreme caution not to potentially spread contamination if running water through the system to sample.)

Decision point	Recommended practice for:	
	Routine monitoring for total coliform in ground water or generic <i>E. coli</i> in surface water	For-cause sampling
Rationale	<p>Captures microbial quality of water contacting produce.</p> <ul style="list-style-type: none"> Total coliforms in surface water are not a reliable indicator of microbial water quality, because they include many environmental species that do not correlate with fecal contamination or pathogen presence. For surface water generic <i>E. coli</i> is an imperfect indicator but is more relevant indicator, as it is more closely associated with fecal contamination and better reflects conditions that could support the presence of human pathogens. 	<p>To assist in identifying the location within the ag water distribution system where contamination occurred/may be occurring.</p>
When to sample	<p>If no prior baseline sampling has been established, take four 250 mL samples at one-minute intervals 30 days prior to the first crown flower development or as practical as possible (i.e., considering your water availability and seasonal water distribution system activation for each crop production block); combine into one 1-liter composite sample; continue scheduled sampling routine at designated timepoints.</p>	<p>After conditions that elevate the indicators of fecal contamination [e.g., after rainfall ($\geq 0.5''$ in 24 h in surface water and for well water $\geq 2''$ in 72 h), runoff, flooding].</p>
Rationale	<p>Builds a baseline useful for continued trend and pattern analysis over time.</p>	<p>Increases assessment-based information when the indicators of fecal contamination are elevated.</p>
How often to sample	<p>When beginning a water testing program, for surface water collect a minimum of 3 samples separated by at least 48 h over a one-month period.</p> <p>Sample routinely thereafter, based on your ag water assessment (e.g., weekly/monthly during growing season).</p>	<p>Depends on the test result indicating an elevated risk of fecal contamination. Two tests within 96 h, depending on follow-up system assessments and initial re-test results.</p>

Decision point	Recommended practice for:	
	Routine monitoring for total coliform in ground water or generic <i>E. coli</i> in surface water	For-cause sampling
Rationale	Creates a baseline from which trends and patterns can be analyzed over time.	Informs mitigation or corrective action decisions.
How much to sample	<p>Surface water:</p> <ul style="list-style-type: none"> Collect four 250 mL grab samples from the irrigation source (e.g., at different times or locations as defined in the protocol) into sterile containers. Combine the four 250 mL portions into a single sterile 1-liter composite bottle. Mix/homogenize the 1 L composite thoroughly (e.g., by inverting the bottle several times). Aseptically transfer 100 mL from the well-mixed 1 L composite into the lab submission container for analysis. <p>Well water: 1-liter samples; submit sample to lab for filtering, backflush, and analysis of ≥ 100 ml</p>	10-liter sample or Moore swabs for human pathogen investigations.
Rationale	<p>Although indicators (e.g., generic <i>E. coli</i> for surface water and total coliforms and generic <i>E. coli</i> for groundwater) are typically present in higher numbers than human pathogens, their concentrations may still be below detection limits in small-volume samples, necessitating composite or large-volume (10–50 L) sampling for accurate assessment.</p> <p>Patterns and trends over time provide more meaningful risk insight than single data points; however, extreme outliers should always trigger immediate investigation.</p>	Larger volumes improve detection of human pathogens present in low concentrations. Develop a plan in advance for how to interpret and act or follow-up on positive samples.

Decision point	Recommended practice for:	
	Routine monitoring for total coliform in ground water or generic <i>E. coli</i> in surface water	For-cause sampling
What else to record	<p>Collect environmental metadata (e.g., turbidity, water temperature, weather-related data, time of day).</p>	<p>Collect historical environmental data, if contamination occurred in the past:</p> <ul style="list-style-type: none"> • Relevant weather data (e.g., flooding, rainfall, ambient temperatures, wind speed and direction, etc.). • Evidence of human (e.g., dredging, recreational use, etc.) or animal feeding operations and changes in management activity, wildlife activity - both nearby and direct access that may affect microbial water quality.
Rationale	<p>Enhances interpretability; supports predictive risk assessment over time.</p>	<p>Augments investigation of causality.</p>
How to use results	<p>Patterns over time typically provide the most value; however, consistently elevated levels or extreme outliers (single sample) should be investigated and addressed promptly.</p>	<p>Use results to guide discovery, corrective action, and continuous improvement and not to trigger fear or overcorrection. For pathogen detections, a positive result requires prompt attention; follow your pre-determined plan for acting on a pathogen-positive result.</p>

Resources and References

- Abou Seeda MA, Yassen AA, Abou El-Nour EAA, Hammad SA. 2020. Management of furrow irrigation technology and its risk assessments: A review. *Middle East J App Sci.* 10:590-616.
- Belias AM, Sbodio A, Truchado P, Weller D, Pinzon J, Skots M, Allende A, Munther D, Suslow T, Wiedmann M, Ivanek R. 2020. Effect of weather on the die-off of *Escherichia coli* and attenuated *Salmonella enterica* serovar Typhimurium on preharvest leafy greens following irrigation with contaminated water. *Appl Environ Microbiol.* 86(17):e00899-20.
- Boyer R. 2012. Enhancing the safety of locally grown produce: Water use. Virginia Cooperative Extension. [Enhancing The Safety of Locally Grown Produce: Water Use | VCE Publications | Virginia Tech](#)
- Granberry DM, Harrison KA, Kelley WT. 2017. Drip chemigation: Injecting fertilizer, acid and chlorine. [Drip Chemigation: Injecting Fertilizer, Acid and Chlorine | CAES Field Report.](#)
- Lee S, Lemire-Baeten A, Neuhold-Huber K, Whitney L. Contrasting furrow and subsurface drip irrigation effects on groundwater recharge. [Microsoft Word - Methods and Assumption](#)
- NSW Government, Department of Primary Industries. 2019. Melon food safety: A best practices guide for rockmelons and specialty melons. [Melon-food-safety-best-practice-guide.pdf](#)
- Runyan C, Obreza T, Tyson T, Goodman B, Tacker P, Thomas J, Johnson A, Grabow G, Smith B, Dennis S. 2007. Maintenance Guide for Microirrigation Systems in the Southern Region. [FAWN Irrigation Maintenance Guide.](#)
- Scherer T. 2005. Care and maintenance of irrigation wells. North Dakota State University Extension Service. Reviewed and reprinted February 2022. [Care and Maintenance of Irrigation Wells \(AE97\)](#)
- Suslow TV. 1997. Postharvest chlorination – Basic properties and key points for effective disinfection. [8003 Postharv. Chlor. 4.0](#)
- Suslow TV. Chlorination in the production and postharvest handling of fresh fruits and vegetables. [Chlorination of Fruits and Veggies | PDF | Bleach | Disinfectant](#)
- Suslow TV. 2012. Risk assessment of *Salmonella* preharvest internalization in relation to irrigation water quality standards for melons and other cucurbits. [Final report.doc](#)
- UCANR. Maintenance of micro-irrigation systems. [Maintenance of Microirrigation Systems](#)
- VA Tech. Manual for chlorine treatment for drip irrigation systems. [CHLORINATION](#)
- WHO 2017 Principles and practice of drinking-water chlorination. [content](#)

Appendix C.1: Conversion table for calculating the amount of (70%) calcium hypochlorite required to dose specific well volumes at 50 mg/L (ppm).

Pipe Diameter (inch)	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	0.25	0.24	0.23	0.21	0.20	0.19	0.18	0.16	0.15	0.14	0.125	0.1125	0.1	0.0875	0.075	0.0625	0.05	0.0375	0.025
4	1	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10
6	2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20
8	3	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.8	1.7	1.5	1.4	1.2	1.1	0.9	0.75	0.6	0.45	0.3
10	4	3.8	3.6	3.4	3.2	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6	0.4
12	6	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6
16	10	9.5	9	8.5	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	2	1.5	1
20	16	15.2	14.4	13.6	12.8	12	11.2	10.4	9.6	8.8	8	7.2	6.4	5.6	4.8	4	3.2	2.4	1.6

Pipe Diameter (inch)	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	7	6.7	6.3	6.0	5.6	5.3	4.9	4.6	4.2	3.9	3.5	3.2	2.8	2.5	2.1	1.8	1.4	1.1	0.7
4	28	27	25	24	22	21	20	18	17	15	14	13	11	10	8	7	6	4	3
6	57	54	51	48	46	43	40	37	34	31	29	26	23	20	17	14	11	9	6
8	85	81	77	72	68	64	60	55	51	47	43	38	34	30	26	21	17	13	9
10	113	107	102	96	90	85	79	73	68	62	57	51	45	40	34	28	23	17	11
12	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20
16	300	295	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30
20	450	428	405	382.5	360	337.5	315	292.5	270	247.5	225	202.5	180	157.5	135	112.5	90	67.5	45
		**1000 g = 1 Kg																	

How to use these tables:

Step 1: Determine the pipe diameter of your well in inches.

Step 2: Determine the well depth (or pipe length) of your well in feet (The company that constructed the well should be able to provide you with the well depth if you do not have it in your records).

Step 3: Determine the water level in your well (in feet).

Step 4: Subtract the well depth from the water level and this will give you the length of pipe containing water (ft).

Step 5: Using the tables above, match up your pipe diameter with your calculated length of pipe containing water to determine the amount of (70%) calcium hypochlorite required. Example – If you have a well that has a pipe diameter of 6 inches and a length of pipe containing water that is 60 ft, you will use 1.2 oz or 29 g of (70%) calcium hypochlorite to achieve a 50 ppm treatment.

Step 6: Decide what concentration of chlorine is required for the well disinfection. If you want to use a 50 mg/L chlorine solution, use the number that you derived in the table. If you want a **100 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 2**. If you want a **200 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 4**.

Step 7: NOTE – If you are going to weigh out your (70%) calcium hypochlorite in **grams** – **USE TABLE B** – **These numbers are metric.**

Appendix C.2: Conversion table for calculating the amount of (25%) chloride of lime (a.k.a. calcium hypochlorite) required to dose specific well volumes at 50 mg/L (ppm).

Pipe Diameter (inch)	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	0.50	0.48	0.45	0.43	0.40	0.38	0.35	0.33	0.30	0.28	0.25	0.23	0.20	0.18	0.15	0.13	0.10	0.08	0.05
4	2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
6	4	3.8	3.6	3.4	3.2	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6	0.4
8	7	7	6	6	6	5	5	5	4	3.9	3.5	3.2	2.8	2.5	2.1	1.8	1.4	1.1	0.7
10	11	10	10	9	9	8	8	7	7	6.4	5.5	5.0	4.4	3.9	3.3	2.8	2.2	1.7	1.1
12	16	15.2	14.4	13.6	12.8	12	11.2	10.4	9.6	8.8	8	7.2	6.4	5.6	4.8	4	3.2	2.4	1.6
16	32	30	29	27	26	24	22	21	19	18	16	14	13	11	10	8	6	5	3
20	48	46	43	41	39	36	34	31	29	26	24	22	19	17	14	12	10	7	5

Pipe Diameter (inch)	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	14	13.3	12.6	11.9	11.2	10.5	9.8	9.1	8.4	7.7	7	6.3	5.6	4.9	4.2	3.5	2.8	2.1	1.4
4	57	54	51	48	46	43	40	37	34	31	29	26	23	20	17	14	11	9	6
6	113	107	102	96	90	85	79	73	68	62	57	51	45	40	34	28	23	17	11
8	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20
10	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30
12	450	420	405	390	360	330	315	293	270	240	225	203	180	150	135	113	90	68	45
16	900	855	810	765	720	675	630	585	540	495	450	405	360	315	270	225	180	135	90
20	1400	1330	1260	1190	1120	1050	980	910	840	770	700	630	560	490	420	350	280	210	140

**1000 g = 1 Kg

How to use these tables:

Step 1: Determine the pipe diameter of your well in inches.

Step 2: Determine the well depth (or pipe length) of your well in feet (The company that constructed the well should be able to provide you with the well depth if you do not have it in your records).

Step 3: Determine the water level in your well (in feet).

Step 4: Subtract the well depth from the water level and this will give you the length of pipe containing water (ft).

Step 5: Using the tables above, match up your pipe diameter with your calculated length of pipe containing water to determine the amount of (25%) chloride of lime required. Example – If you have a well that has a pipe diameter of 6 inches and a length of pipe containing water that is 60 ft, you will use 2.4 oz or 68 g of (25%) chloride of lime.

Step 6: Decide what concentration of chlorine is required for the well disinfection. If you want to use a 50 mg/L chlorine solution, use the number that you derived in the table. If you want a **100 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 2**. If you want a **200 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 4**.

Step 7: NOTE – If you are going to weigh out your (25%) chloride of lime in **grams** – **USE TABLE D** – **These numbers are metric.**

Appendix C.3: Conversion table for calculating the amount of (5.25%) sodium hypochlorite required to dose specific well volumes at 50 mg/L (ppm).

Pipe Diameter (inch)	(5.25%) Sodium Hypochlorite (Liquid Measure in fluid ounces)																		
	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
4	8	8.6	8.1	7.7	7.2	6.8	6.3	5.9	5.4	5	4.5	4.1	3.6	3.2	2.7	2.3	1.8	1.4	0.9
6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
8	34	32	31	29	27	26	24	22	20	19	17	15	14	12	10	9	7	5	3
10	56	53	50	46	45	42	39	36	34	31	28	25	22	20	17	14	11	8	6
12	80	76	72	68	64	60	56	52	48	44	40	36	32	28	24	20	16	12	8
16	128	122	115	109	102	96	90	83	77	70	64	58	51	45	38	32	26	19	13
20	176	162	153	145	136	128	119	111	102	94	85	77	68	60	51	43	34	26	17

Pipe Diameter (inch)	**This Table uses Metric Units**																		
	(5.25%) Sodium Hypochlorite (Liquid Measure in milliliters)																		
	Length of Pipe Containing Water (ft)																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
2	58	56	53	50	47	44	41	38	35	32	30	27	24	21	18	15	12	9	6
4	266	253	239	226	213	200	186	173	160	146	133	120	106	93	80	67	53	40	27
6	600	570	540	510	480	450	420	390	360	330	300	270	240	210	180	150	120	90	60
8	1000	950	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	100
10	1700	1615	1530	1445	1360	1275	1190	1105	1020	935	850	765	680	595	510	425	340	255	170
12	2400	2280	2160	2040	1920	1800	1680	1560	1440	1320	1200	1080	960	840	720	600	480	360	240
16	3800	3610	3420	3230	3040	2850	2660	2470	2280	2090	1900	1710	1520	1330	1140	950	760	570	380
20	6300	5985	5670	5355	5040	4725	4410	4095	3780	3465	3150	2835	2520	2205	1890	1575	1260	945	630

**1000 mL = 1 L

How to use these tables:

- Step 1:** Determine the pipe diameter of your well in inches.
- Step 2:** Determine the well depth (or pipe length) of your well in feet (The company that constructed the well should be able to provide you with the well depth if you do not have it in your records).
- Step 3:** Determine the water level in your well (in feet).
- Step 4:** Subtract the well depth from the water level and this will give you the length of pipe containing water (ft).
- Step 5:** Using the tables above, match up your pipe diameter with your calculated length of pipe containing water to determine the amount of (5.25%) sodium hypochlorite required. Example – If you have a well that has a pipe diameter of 6 inches and a length of pipe containing water that is 60 ft, you will use 12 oz or 360 mL of (5.25%) sodium hypochlorite.
- Step 6:** Decide what concentration of chlorine is required for the well disinfection. If you want to use a **50 mg/L chlorine solution**, use the number that you derived in the table. If you want a **100 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 2**. If you want a **200 mg/L chlorine solution**, use the number that you derived in the table **multiplied by 4**.
- Step 7: NOTE** – If you are going to weigh out your (5.25%) sodium hypochlorite in **milliliters** – **USE TABLE F** – **these numbers are metric.**

