National Food Safety Guidelines for Cantaloupe and Netted Melons

Appendix E: Environmental Monitoring

Version 2.0
February 2026

TABLE OF CONTENTS

ABBREVIATIONS AND DEFINITIONS

Terminology	Definitions
Corrective action	To eliminate the cause of a detected non-conformity or other undesirable situation and prevent recurrence.[1]
Environmental Monitoring Program (EMP)	A process of sampling and testing to evaluate a facility's overall environment for undesirable microorganisms.
Resident contamination	An isolate that is repeatedly found, indicating a potential lapse in GMPs or existence of an undiscovered niche which has allowed for a harborage site to be established. It is likely that this harborage is continually re-contaminating the facility with increasing potential to contaminate produce. Corrective actions need to be aggressively implemented to seek out and eliminate resident isolates and the factors that allowed them to establish a harborage. (IFPA, 2018)
Routine swabbing	The practice of collecting samples from various surfaces with a packing facility or on packing equipment to test for indicators of or the presence of microbial contamination.
Sanitize/Sanitizing/ Sanitization	Adequately treating any cleaned surface by a process that is effective in destroying vegetative cells of pathogens, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for the consumer.[2]
Transient contamination	A one-time isolate whose repeated presence via swabbing is not detected (minimum 3 consecutive negative results). It's likely that GMPs are effectively implemented. Because *Listeria* may be continually re-introduced from incoming ingredients, implementation of GMPs is essential to keep it controlled. Given the ubiquitous nature of *Listeria*, an occasional isolate will likely be detected with an aggressive EMP. Be suspicious if test results are always negative. (IFPA, 2018)
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.
Validation	Obtaining and evaluating scientific and technical evidence that a control measure, combination of control measures, or the food safety plan as a whole, when properly implemented, is capable of effectively controlling the identified hazards.[3]

[1] FDA. 2014. Presentation on corrective and preventive action basics. CDRH-Learn-Presenation--Corrective-and-Preventive-Action-Basics.pdf

[2] Definition in the Produce Safety Rule

[3] Definition in the Preventive Controls Rule

Terminology	Definitions
Vectoring	Additional swabs taken around an initial positive site to see if the contamination has spread (Nicholl, 2021).
Verification	The application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine whether a control measure or combination of control measures is or has been operating as intended and to establish the validity of the food safety plan.[2]

AN INTRODUCTION TO ENVIRONMENTAL MONITORING

Environmental monitoring is the systematic evaluation of microorganisms present in the food processing environment for the purpose of verifying the effectiveness of cleaning and sanitization activities, detecting emerging contamination, and preventing the establishment of harmful pathogens such as *Listeria monocytogenes* and *Salmonella*. Netted melon are grown and hand-harvested in fields located in uncontrolled rural or urban settings and have contact with bins, trailers, and people, and no lethality step exists. Because of the contamination risk that comes with an outdoor growing environment, an environmental monitoring program (EMP) is a very important proactive program for food safety. A properly designed EMP functions as both a verification tool and an early-warning system, enabling the facility to identify contamination before it reaches food-contact surfaces or product (IFPA, 2018).

The role of environmental monitoring extends far beyond simply collecting swabs on a predetermined schedule. A mature EMP actively seeks out the conditions under which pathogens survive, grow, and spread. This philosophy, often described as "seek and destroy", is emphasized throughout industry guidance as the most effective approach to preventing persistent environmental contamination.[4, 5] The goal is not merely to confirm cleanliness, but to intentionally search for sites where *Listeria* and other predictive indicator organisms are most likely to exist and form biofilms: drains, floor cracks, equipment undersides, hollow rollers, brush beds, water accumulation points, and any location where organic material and moisture intersect.

Environmental monitoring merges microbiology, facility and equipment design, sanitation science, and risk assessment into a unified control approach. As described by FDA in its 2022 draft *Listeria* guidance, EMPs serve as a critical verification measure under preventive controls frameworks, demonstrating whether sanitation procedures are adequately controlling environmental pathogens.[6] The sampling plan provides insight into the microbiological baseline of the facility, while ongoing trend analysis helps identify recurring patterns, areas of vulnerability, and indicators of deteriorating sanitary conditions.

Fresh produce packinghouses, including melon operations, present unique challenges compared to traditional ready-to-eat (RTE) food plants. The survey of environmental monitoring practices by Critzer et al. (2024) found significant variability in how produce facilities design their EMPs, with many operations undersampling Zone 2 surfaces and relying too heavily on ATP as a proxy for microbiological risk.[7] The study highlights the critical need for produce-specific EMPs that focus on realistic contamination routes for water-rich, soil-borne commodities such as cantaloupe. It is critically important that programs are designed and evaluated based on risk to maximize the efficiency of the program.

In summary, an effective EMP is not a static compliance activity but a dynamic, risk-based system that informs sanitization performance, facility design decisions, and management oversight. When properly implemented and routinely evaluated, an EMP strengthens preventive controls, supports early detection of environmental hazards, and provides objective evidence that sanitization programs are functioning as intended, ultimately reducing the likelihood that pathogens will reach food-contact surfaces or finished product.

[4] Cornell University and Neogen. 2025. Environmental monitoring handbook for the food and beverage industries. 2nd Edition Neogen® Environmental Monitoring Handbook

[5] IFPA. 2018. Guidance on environmental monitoring and control of *Listeria* for the fresh produce industry – 2nd Edition. International Fresh Produce Association. Guidance-on-environmental-monitoring-and-control-of-listeria.pdf

[6] FDA. 2022. Control of *Listeria monocytogenes* in ready-to-eat foods: Guidance for industry, Draft guidance. Guidance for Industry

[7] Critzer F, Hamilton AM, Melendex M, Danyluk MD, Strawn LK. 2024. Survey of environmental monitoring practices in fresh produce packinghouses. Food Prot. Trends. 44:102-110.

SCOPE OF THIS DOCUMENT

This document covers EMPs for all areas where cantaloupes are handled postharvest. EMPs in netted melon packing and processing facilities should include food-contact surfaces, equipment, drains, floors, walls, and employee areas. This guidance can be helpful for both wet and dry packing environments, including field-packing operations, specifically food-contact surfaces like harvest tools and equipment. Operations that incorporate spray bars, dump tanks, hydrocoolers, or recirculated water should consider additional risks associated with moisture accumulation and aerosolization.

VALIDATION AND VERIFICATION

Environmental monitoring plays a dual role within a food safety system by supporting both **validation** and **verification** of sanitation and other non-process preventive controls.

Validation of your EMP and sanitation controls

The validation process is an intentional study aimed at providing scientific and technical evidence that a sanitation program or environmental control strategy is capable of controlling the identified hazard. This should be conducted to account for expected and worst-case or reasonably foreseeable conditions. In the context of an EMP, validation demonstrates that cleaning and sanitization procedures, equipment design, and operational practices can effectively remove or control pathogens such as *Listeria monocytogenes* or *Salmonella* before routine production begins or after significant changes. As examples, validation efforts should be conducted:

- During the initial development of the EMP and sanitization procedures
- After installation of new equipment or facility modifications
- When significant changes occur in products, processes, or sanitization chemistry

The outcome of validation efforts establishes confidence that the EMP is built upon effective and scientifically sound control measures, and that routine monitoring activities are meaningfully designed to be able to control risk. The Environmental Monitoring Handbook, written and published by Cornell University and Neogen, has a guide (Chapter 2) on how to perform validation within an EMP.[4]

Verification of your EMP and sanitation controls

Verification activities are used to confirm, on an on-going basis, that validated sanitation and environmental controls are being implemented consistently, and that they continue to be appropriate during normal operations. Unlike validation, verification activities are a routine and ongoing program that are embedded within daily or weekly operational activities.

According to the Environmental Monitoring Handbook, verification monitoring programs typically include routine sampling of Zones 1–3, and are used to verify the consistent application of sanitation process controls and environmental pathogen control programs.[4] Verification activities may include:

- Routine environmental swabbing of food-contact and adjacent non-food-contact surfaces
- Scheduled sampling during production to understand movement along the facility
- Trending and review of environmental data to detect emerging issues

Verification activity informs on whether a facility is doing what the validation work evaluated and if it is working as expected (i.e., results are consistent with what was seen in the validation study). Verification results that are out of spec (e.g., positive indicator results) will trigger corrective actions, investigative sampling, and, depending on the results, may indicate that your EMP and sanitation controls need to be re-validated.

ENVIRONMENTAL ZONING

Environmental zoning (Table 1) is essential for structuring sampling intensity, interpreting results, and setting corrective actions proportional to risk. A mature EMP considers zone hierarchy, with results in higher-numbered zones designed to inform that preventive actions may need to be implemented proactively before contamination reaches Zones 1–2.

- **Zone 1: Direct food-contact surfaces.** These surfaces pose the highest risk because contamination at these points directly contacts the product. Routine pathogen testing in Zone 1 is generally not recommended in an EMP because it may trigger regulatory implications. Rather, it is recommended that Zone 1 is monitored using microbial indicators, ATP, or other verification tools (IFPA, 2018; FDA, 2022 Draft Guidance).
- **Zone 2: Adjacent non-contact surfaces (frames, equipment housing).** These surfaces are close enough to Zone 1 to transfer contamination through splashing, dripping, aerosolization, or employee handling. Persistent positives in Zone 2 require immediate attention, as they may indicate encroachment toward food-contact areas. Additionally, contamination may flow from lower zones to higher (i.e., Zone 1 contaminating Zone 2); make sure to consider all paths when doing investigation activities.
- **Zone 3: Non-production surfaces inside facility.** Although not directly connected to production, contamination in Zone 3 can spread to Zones 1–2 through traffic patterns, drains, employees, air, or equipment movement.
- **Zone 4: Outside/employee areas.** These areas provide context about overall sanitary culture and potential indirect vectors. While lower risk, recurring positives in Zone 4 suggest systemic issues with potential to come into lower zones in the area.

Table 1. Classification and examples of environmental sampling sites

Zone	Examples (may differ depending on site/facility)
ZONE 1: High-risk areas - Direct food-contact surfaces where contamination directly impacts food safety.	Conveyor belts, cutting boards, harvest bins, rollers, brushes, graders, packing tables, harvest gondolas, harvest tools, harvesters
ZONE 2: Adjacent areas - Non-food-contact surfaces close to Zone 1 that could contaminate Zone 1 indirectly.	External surfaces of equipment (e.g., housing, framework) control panels, handles, overhead or adjacent supply lines (e.g., water lines that may drip or form condensation), fans, conduit, wiring housings, or cable runs attached to or near equipment

Zone	Examples (may differ depending on site/facility)
ZONE 3: Peripheral areas - Non-food contact surfaces further removed but within the netted melon packing and processing environment.	Non-production surfaces such as floors, walls, drains, storage shelves in processing areas, overhead utility lines or supply lines not directly above equipment but within processing zones
ZONE 4: Remote areas - Areas outside the food processing area that could indirectly impact Zones 1–3.	Locker rooms, offices, hallways, break rooms, maintenance areas.

DESIGNING AND ENVIRONMENTAL MONITORING SAMPLING PLAN

A sampling plan must be statistically meaningful, operationally feasible, and directly aligned with the risk characteristics of the facility. There is no set right or wrong plan; plans must be intentionally designed and thorough for unique conditions. Sample numbers should increase during periods of heightened vulnerability such as during high seasonal production, equipment repairs, and any changes in conditions that may result in increased microbiological activity.

Your sampling strategy should include sampling during both pre-operational and operational schedules because:

- Pre-operational sampling verifies whether sanitization activities successfully removed contaminants before production begins.
- Operational sampling, conducted during or after production, determines whether contamination develops while equipment is in use and captures potential niches that are exposed during production (e.g., bacteria move around from vibrations, dripping water, traffic movement, etc.).

An EMP must be proactive, risk-based, and documented. Prior to sampling, a sampling plan should be prepared. When based on a predetermined plan, sampling will help to ensure efficiency and thoroughness of monitoring the environment, as well as increase the probability of detecting any pathogens that may be present. The sampling plan should clearly define:

- **Sampling methods:** These are identified and discussed later in this document. These tools will vary based on the device used, the site to be samples, and type of test being performed (ATP, microbial indicator methods, microbiological pathogen detection methods, etc.).
- **Sampling site selection and rotation:** Sites should be selected based on their proximity to exposed product (zone classification), likelihood to harbor or transfer microorganisms, cleanability, equipment design, and normal operating conditions, including moisture, traffic, and seasonal influences. Consideration should also be given to historical results and trend data, with higher-risk or previously problematic areas prioritized for routine or intensified sampling. By intentionally targeting sites where contamination is most likely to occur, persist, or spread, the EMP can function as an effective verification and early-warning system rather than a purely compliance-driven activity.

- **ATP sampling site selection:** ATP testing is primarily used to verify the effectiveness of cleaning procedures, rather than sanitization or pathogen control. ATP is most appropriate for food-contact surface and adjacent areas that are expected to be clean following cleaning procedures. ATP is typically used for Zones 1-3.
- **Indicator site selection:** Indicator organism sampling is used to verify the ongoing effectiveness of sanitization programs and assess the hygienic condition of the processing environment. Sampling sites should include food-contact and non-food-contact surfaces across Zones 1, 2, 3, with emphasis on areas that are exposed during normal operations and may serve as transfer points. In-process sampling of Zone 1 sites provides data that can indicate a potential loss of sanitary control or conditions that could lead to product contamination. If used, form an action plan in case results are out-of-tolerance. Indicator results from Zone 1 sites may also be used to help define appropriate production run times for specific lines and, when supported by trend data, can provide scientific justification for extended run times. In addition, indicator testing of Zone 1 and Zone 2 sites can serve as a supplementary tool for monitoring the condition/degradation of equipment and sanitization performance over time; this can help inform decisions related to preventive maintenance or repairs.
- **Frequency and number of samples:** The EMP must clearly define both how many samples will be collected during each sampling event and how often these sampling events will occur. These parameters establish the EMP's operational rhythm and ensure that environmental data provide a reliable and meaningful assessment of the facility's control of *Listeria*, *Salmonella*, and other environmental pathogens.
  - **How many samples are taken per event?** The number of samples collected during each event must also reflect the complexity and size of the facility – there is no set "right" or "wrong" number. For example, a facility with multiple wash lines, flumes, conveyors, and drains cannot rely on a small sample set without risking blind spots and exposure. At a minimum, each event should gather samples across zones 1–3 to maintain a balanced understanding of environmental conditions. However, higher-risk Zones will require heavier sampling. It is imperative that the number of sample are defined and documented based on risk, history, and environmental conditions.
  - **Guidance Recommendations:**
    - The FDA in the *Listeria monocytogenes* guidance for ready-to-eat foods recommends that even the smallest processors collect samples from at least 5 sites of FCS and 5 sites of non-FCS on each production line for RTE foods.
    - In their guidance on environmental monitoring and control of *Listeria*, the International Fresh Produce Association mentioned that there is no right answer as to frequency and number of swabs, and one size doesn't fit all. They further suggest that a large facility could start with 50-60 swabs per shift per week divided as follows:
      - 25% taken after sanitization across all Zones 1-4
      - 50% taken mid-shift in Zones 2-3
      - < 25% in zone 4 with some Zone 1 swabs taken after the equipment has been running.
    - Verification of sanitization activities (indicators): When used for verification of sanitization efficacy, sampling should take place after every sanitization cycle, and prior to, production startup to allow for trending of results and early identification of issues.[4]

  - **How often do sampling events occur (daily, weekly, biweekly, monthly, quarterly)?** There is no single "correct" sampling frequency applicable to all facilities. Instead, sampling must be tailored to the conditions under which each facility operates. A small, low-volume operation with limited water activity may appropriately adopt a lower sampling frequency than a large, hydrocooler-equipped facility handling high daily throughput. Conversely, facilities with complex equipment, past environmental positives, or recurring sanitization challenges may require more intensive sampling to maintain adequate oversight. In short, thorough and intentional design is needed for each and all facilities/sites.

- **Rotation of sample sites:** A well-designed EMP must ensure that sampling is distributed across the facility in a manner that reflects both the inherent risks of different zones and the operational realities of netted melon handling. Rotating sample sites allows the facility to systematically scan the environment, rather than repeatedly sampling only a limited number of familiar areas. While some high-priority sites may be sampled every week due to their elevated risk, the broader rotation ensures that less obvious or peripheral areas are also evaluated regularly. It is important to consider the following:
  - Areas in different zones are sampled with a defined frequency.
  - High-risk equipment or sites (based on historical information) are prioritized within these rotations.
  - Previously positive sites are also included with more frequency, until trends from historical data collection have been stabilized.
  - Previously employed corrective actions should be revisited to ensure the corrections hold and risk controlled.
- **Vectoring** is a targeted environmental monitoring technique used after a positive environmental sample is detected. Its primary purpose is to determine the source, extent, and direction of contamination so that appropriate corrective actions can be implemented and verified. Pathogens often move through the facility on water, air, equipment, boots, and wheels. Contamination discovered on one surface may originate from a drain several feet away, a crack in the floor where water accumulates, a hollow roller not adequately disassembled, tires on forklights, and/or a poorly designed conveyor component that collects debris. Vectoring is an important activity that allows the facility to better understand the risk and trace contamination using systematic sampling and spatial analysis.[8]
  - When a positive occurs, sanitization should be paused temporarily so the area can be sampled without disturbing the area. The investigator should swab outward in multiple directions (above, below, to the sides, upstream in the production line, and downstream) where water, movement, or product flow may carry organisms.
  - Sampling continues until boundaries are identified: the investigator seeks the last point where the contamination is present and the first point where it disappears. These boundaries help triangulate the most likely harborage site.
  - These efforts allow the development of a contamination map, which can be used to implement corrective actions, identify larger movement trends, and ensure appropriate situational response.

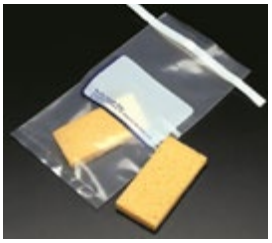
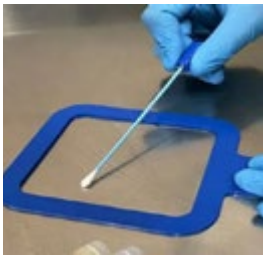
[8] Vector Swabbing 101 - Safe Food Alliance

Sampling Methods and Target Analytes

Sampling tools

Various commercial sterile sample collection tools are available and primarily come in three forms (Table 2).

Table 2: Description and typical use of different sampling tools

Sampling Tool	Description	Typical use	Reference Image
Sponge in a bag	Small sterile sponge pre-hydrated or used with a transport buffer, contained within a sterile sampling bag.	Sampling larger or irregular environmental surfaces (e.g., belts, brushes, rollers, drains, floors).	
Sponge with a handle	Small sterile sponge attached to a handle and supplied in a bag with transport buffer.	Sampling hard-to-reach areas, undersides of equipment, hollow framework, and areas requiring extended reach.	
Cotton swab	Small dry or moistened swab resembling a Q-tip, typically supplied in a tube containing transport buffer.	Sampling small, targeted areas such as cracks, crevices, seams, and small food-contact points.	

Sampling procedure

1) Pre-label the bags or tubes with sample number and record/log the sample number with the sample location. Make sure this clearly links to the sampling plan for on-going data analysis and records.
2) Wash hands with soap up to the elbows, rinse, and dry with a clean or disposable towel.
3) If gloves are loose-fitting, open the sample bag or tube before putting on gloves. Otherwise, put on gloves before removing sponge/swab from packaging. For sponges in a bag, squeeze out excess buffer before extracting the sponge/swab from the bag.
4) Follow the manufacturer's instructions for using the swabbing product.
5) Generally, many sponges recommend swabing an area of about 12 x 12 inches (30 x 30 cm) using uniform back and forth motion. See Chapter 3 of the Environmental Monitoring Handbook for example of a sampling technique.[4]
6) After swabbing, sanitize the area you swabbed.
7) Transport (or ship overnight) samples with cold packs (do not use wet ice).
8) Use validated swab/test methods for the surface and type of buffer in the sponge/swab.
9) Follow lab QA/QC procedures for culture or rapid methods.

Target Analytes:

When designing the EMP and conducting validation and verification activities, it is essential to identify the adequate target analyte. Different target analyties achieve different goals. Undertanding these target analytes is important for the design and interpretation of your EMP. A summary of these target analytes is found Table 3.

Table 3. Types of tests for an EMP and objectives.

Type of test	Description	Objective
ATP	An ATP meter is used to quickly assess surface cleanliness by measuring adenosine triphosphate (ATP) levels, which may indicate biological contamination. After swabbing a surface, the sample is placed in the meter, which quantifies ATP through a luminescence reaction, with results displayed in relative light units (RLU). Higher RLU readings suggest higher contamination levels, allowing for immediate corrective action if cleanliness standards are not met. **Limitations:** Little correlation with microbial load or presence of pathogens	The entry point for monitoring **Generally used for verification of cleaning procedures** Reading and acceptance should be relative to historical data and observations as factors such as the type of ATP unit, different surfaces, etc.
Indicator organisms	Target indicator organisms will vary depending on the type of operation and zoning. For wet environments, *Listeria* spp. are common targets. Indicator organisms: • Serves as early warning of potential pathogen presence. • *Listeria* spp., APCs, generic *E. coli*, *Enterobacteriaceae*.	Validation and verification of sanitization procedures. Help determine the hygienic status of the equipment. Microbial testing should be reserved for applications where delayed results are acceptable (e.g., trend analysis, verification of sanitization programs, periodic risk-based assessments).
Pathogens	For dry environments, environmental monitoring may focus on *Salmonella* spp. However, note that *Salmonella* spp. can survive and thrive in wet facilities as well as dry. Pathogens: • Can be used to verify control or corrective action measures. • Useful in "seek and destroy" programs. • *L. monocytogenes*, *Salmonella*	Validation and verification of sanitization procedures, and strategies for pathogen control. Helps identify sources of environmental contalmination and pathways for pathogens.

CORRECTIVE ACTIONS AND TESTING INTERPRETATION

Effective corrective actions are the cornerstone of a successful EMP. While routine sampling provides information about the microbiological status of the facility, corrective actions determine whether the site is capable of eliminating contamination, preventing reoccurrence, and maintaining long-term environmental control. Corrective actions must not only address the surface that tested positive but also investigate and eliminate the underlying conditions that allowed contamination to develop in the first place (FDA, 2022; IFPA, 2018).

Growers and packers should prioritize indicator organism testing (e.g., APC, coliforms, *Listeria* spp.) for routine environmental monitoring. Indicator organisms offer increased ability to find emerging risks and zones of concern since they are in greater abundance, while pathogens may be fewer in number and harder to proactively identify by EMPs. Environmental monitoring should be optimized to learn as much, and as proactively, as possible. This increases the predictive value of the effort.

Pathogen testing is advisable when there is reason to suspect contamination or when there is evidence that a prerequisite program or food safety process has failed or is out of control (IFPA, 2018). In addition, when testing for a pathogen, it is critical to have a clearly defined, pre-established procedure for responding to a positive result. Have an action plan for positive results and respond immediately by implementing and documenting the corrective actions performed. This includes decisions on product disposition, traceback, intensified sanitization, repeat sampling post-cleaning, and communication plans within the organization. Without clear procedures, pathogen testing may unintentionally create operational and regulatory challenges; this is especially true when testing includes the need to hold or divert product while awaiting confirmatory results.

1) **Response to positive results based on zone**

   Upon receiving an out-of-spec or positive EMP result, the facility must take prompt, documented action. The first step is to assess the location and zone:

   - **Zone 1 (food-contact surfaces):** Zone 1 surfaces are product contact and a high risk if contaminated. Although the industry often avoids routine pathogen testing in Zone 1, Zone 1 surfaces can be tested for indicator organisms (e.g., generic *E. coli*, coliform, *Listeria* spp., etc.). When a sample is *Listeria* spp. positive, an immediate response is required, including procedures such as holding product, equipment teardown procedures, verification swabs (2-3 rounds to verify cleaning/sanitization) and vectoring samples from the positive site as part of a thorough, rapid, and targeted investigation.
   - **Zone 2:** A Zone 2 detection generally indicates the potential for contamination that may then be capable of moving toward Zone 1 food-contact surfaces. Repeated findings are especially concerning and suggest a resident harborage that must be aggressively addressed. When evaluating Zone 2 findings, make sure to review Zone 1 findings in the same area to further establish that contamination is controlled at Zones 2 - 4

2) **Perform immediate corrective actions**

   - Pause sanitization temporarily (to preserve evidence for vectoring).
   - Restrict traffic around affected area.
   - Hold product if Zone 1, or at management's discretion for Zones 2–3.
   - Notify food safety and sanitation leaders.
   - Implement equipment teardowns, cleaning/sanitization procedures, verification samples post cleaning/sanitization, rule out widespread contamination with vectoring swabs.
   - Document any/all corrective actions

3) Conduct root cause analysis

When you receive an out-of-spec or positive test result, conduct a root cause analysis including taking additional swabs around the initial positive site in a star-burst fashion (vectoring).[8] This exercise will help determine if the contamination has spread from the original positive site. After cleaning and sanitizing the implicated area, swab the site and surrounding area again to evaluate efficacy of the cleaning procedures. Do this until three swabs return negative results consecutively. This procedure and effort helps determine whether contamination is transient or resident.

- Root cause actions may include activities such as:
  - Complete equipment teardowns, examining for evidence of biofilm, poor sanitization, and material breakdown
  - Inspecting equipment for entrapment points, hollow rollers, and cracks
  - Examining water flow, drainage, condensation, and pooling
  - Reviewing sanitization procedures and equipment teardown practices
  - Evaluating employee and equipment movement (traffic patterns), tool use and storage
  - Assessing recent changes inside and outside the facility (e.g., maintenance, seasonal surge, weather events, adjacent activities next to the facility)
- Implement long-term corrective actions (from investigation)
  - Revisit routine sampling plans, sanitization programs, traffic patterns, etc. following a root cause finding. There may be ongoing changes needed to prevent future contamination/ harborage.
  - Provide training and a post-event update for the leadership and operational team. It is important to educate the entire team on relevant findings, concerns, and keep teams engaged in the monitoring practice.
- Verification procedures
  - Revisit past events and corrective actions to ensure that the corrective action was effective.
  - Document these activities, and if needed, re-open the root cause assessment if signals indicate the efforts were not successful.

DATA REVIEW

EMP oversight and review responsibilities

EMP results should be reviewed by a designated food safety team, which at a minimum includes food safety leadership, sanitation management, and operations or maintenance representatives; however, it is also highly valuable to include upper business leadership. This comprehensive and collaborative review ensures that trends are interpreted in the context of sanitation practices, equipment design, traffic flow, and operational changes. Additionally, it is critical for upper leadership of the business and facility to understand the trends being observed, especially recurring threat/observations, and to ensure resources and plans are allocated appropriately. EMP is a critical business function that proactively reduces risk and ensures regulatory and legal compliance.

The review should evaluate:

- Indicator and pathogen results by zone, site, and surface type.
- Overall frequency and recurrence of positives.

- Trend analysis of the data – looking for patterns across sites, zones, organisms, shifts, seasons, etc. Careful consideration of factors in/outside the facility may be needed (e.g., weather, adjacent land operations).
- Effectiveness and timeliness of corrective actions, thoroughness of documentation, and overall review.
- Alignment with historical baselines and risk expectations.
- Consideration of new sites based on prior results.
- Review of methods being used to ensure continued appropriateness, evaluation of new swabbing materials for potential advantages, etc.
- Review of service providers (e.g., laboratories, sampling companies, etc.).

FDA resources (e.g., Table 6 of the FDA's Draft Guidance to Industry, Control of *Listeria monocytogenes* in Ready-To-Eat Foods) may be used as a reference framework for trend interpretation and escalation logic; however, facilities should establish site-specific baselines and action thresholds based on product risk, environment, and historical data rather than relying solely on generic benchmarks.[9]

Decision authority and escalation thresholds

The EMP should define clear decision authority and escalation triggers, including:

- Routine review: Conducted by food safety or sanitation leadership for single, non-recurring indicator findings in lower-risk zones.
- Management escalation should be included on routine activities, but are critical when:
  - Repeated positives at the same site or equipment.
  - Expanding positives across adjacent sites or zones.
  - Emerging trends suggesting harborage, ineffective sanitization, or traffic-related spread.
  - Any pathogen detection in the environment.

Escalation thresholds should be collectively designed, documented, and include information such as defined timelines for events (i.e., communication information, corrective action plan, resampling activities/results, and verification activities).

CONDUCT AN EMP ANNUAL REVIEW.

Every mature EMP must include, at a minimum, a structured and documented **annual assessment** that evaluates the effectiveness of the program and identifies areas for improvement.

Examples of what the annual review should include are:

- Trend review: Analysis of indicator and environmental results to identify recurring contamination, emerging hotspots, or seasonal patterns.
- Revision of sampling sites: Updates to the site list based on structural or equipment changes, flow modifications, new lines, or altered sanitization practices.
- Reassessment following major operational changes: Including new equipment installations, sanitization method changes, construction, or layout updates that could affect microbial harborage or flow paths.

[9] FDA. 2017. Control of *Listeria monocytogenes* in Ready-To-Eat Foods: Guidance to Industry. Guidance for Industry

- Even if no changes to the facility/equipment have occurred, ensure the plan includes evaluating equipment and facilities over time. Facilities and materials breakdown over time and as they do, new harborage points may be introduced.
- Consider including "swabathons" which are a large number of swabs taken at one time to provide a more thorough assessment of the facility at that point in time. Swabathons can be used to verify the adequacy of sampling sites, provide information on whether new sites need to be included, correlate additional organisms to routine targets, and consider timing activities at different times of production to give additional insights on patterns.

RECORDS & VERIFICATION

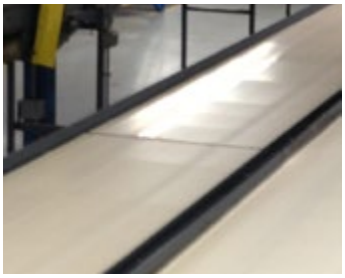
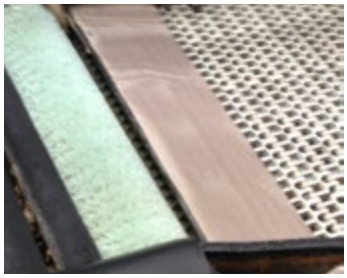
Every mature EMP must include, at a minimum, a structured and documented annual assessment that evaluates the effectiveness of the program and identifies areas for improvement.

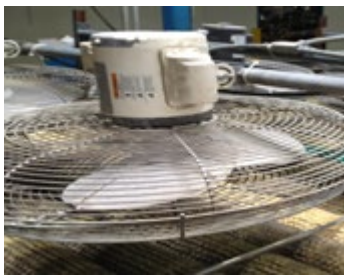
Examples of what the annual review should include are:

- Maintain logs of sites, results, communication events, and corrective actions implemented.
- Document management reviews covering EMP trends.
- Seasonal considerations: Environmental conditions can shift dramatically throughout the growing, harvesting, and packing seasons, and these may significantly influence microbial risks and the performance of sanitation programs. A robust EMP should account for seasonal variability and adjust sampling intensity, sampling site selection, and corrective actions accordingly. For example:
  - Seaons of heavy mud and field debris for incoming product/equipment.
  - Seasonal temperature changes leading to fluctuations in outside/inside temperatures, causing condensation.
  - Impacts from hydrocooling and other cooling activities (forced-air systems, tarps, etc.).
  - Monsoon seasons in some states (e.g., AZ, NM) that bring high humidity and moisture.
  - Periods of high dust, wind, etc.
  - Late season impacts from culls in the field, repeated field traffic, disease pressure.

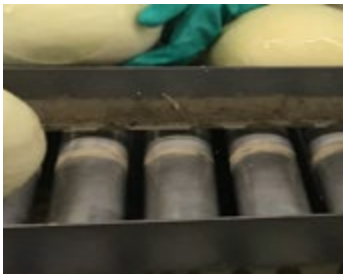
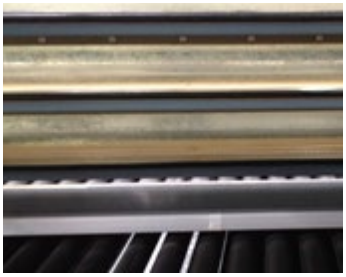
SUPPLEMENTAL MATERIAL: SURFACES OF CANTALOUPE PACKING FACILITIES (FIGURES)

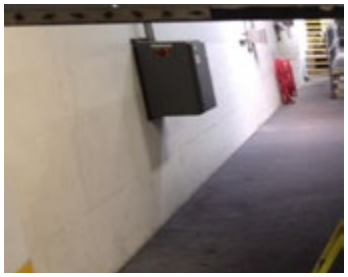
Food-Contact Surfaces

Surface / Sampling Site	Rationale	Figure
Dump tank contact surfaces (walls, bottom, overflow weirs)	First point of product contact where incoming field contamination can be introduced and spread via water and fruit-to-fruit contact	
Conveyors immediately after dump	Early transfer point where contamination may move from receiving to downstream operations	
Conveyor belts (flat contact surfaces)	Continuous contact with multiple melons; belts may retain moisture and organic debris	
Conveyor belt joints and splices	Difficult-to-clean interfaces with increased harborage potential	
Rollers and transfer points	Frequent contact and friction increase the likelihood of cross-contamination	

Surface / Sampling Site	Rationale	Figure
Brushes (bristles or contact surfaces)	Organic load accumulation and moisture retention during washing operations	
Drying tunnel contact surfaces	Potential for air mediated cross-contamination and redistribution of contamination across fruit	
Sorting cups, chutes, and diverters	Repeated direct contact with fruit during grading and packing	
Packing tables and accumulation surfaces	Extended contact time during manual handling operations	
Belt undersides that contact product	Often overlooked during sanitization; may contact fruit during jams or misalignment	

Non-Food-Contact Surfaces

Surface / Sampling Site	Rationale for Inclusion	Figure
Conveyor framework adjacent to belts	Proximity to food-contact surfaces makes may indicate sanitization effectiveness	
Bearings and roller supports	Moisture accumulation and limited access create persistent harborage sites	
Equipment guards and splash shields	Collect debris and water near food-contact areas	
Floors beneath dump tanks and conveyors	Organic load and water accumulation from incoming product	
Floor drains in wash and packing areas	Known pathogen reservoirs and early-warning monitoring sites	

Surface / Sampling Site	Rationale for Inclusion	Figure
Drain covers and surrounding floor	High-risk transition points for contamination spread	
Wall–floor junctions	Difficult-to-clean interfaces that reflect overall sanitization performance	
Structural legs and support columns	Exposed to splash and traffic; often under-cleaned	
Forklift tires and pallet jack wheels	Vectors for moving contamination between facility zones	
Cold storage room floors and walls	Indicator of post-packing environmental contamination trends	

Surface / Sampling Site	Rationale for Inclusion	Figure
Door tracks and thresholds	High traffic areas with moisture and debris accumulation	
Loading dock floors	Indicator of incoming and outgoing contamination pressure	
Waste handling carts or bins	Reflect external pathogen pressure and sanitization controls	
Cold storage room floors and walls	Indicator of post-packing environmental contamination trends	

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