NCMarketReady™

Fresh Produce Safety – Field to Family

A Program of NC Cooperative Extension

Module 6:
Water Quality

Acknowledgments

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Dr. Garry Grabow, Extension Specialist, N.C. State University

Module 6: Water Quality

Estimated duration: *2 hours*

Instructional overview:

The learner will understand:
- Potential sources of contamination (current and prior) of water used for irrigation and processing
- The best management practices for preventing contamination and protecting water quality on the farm
- Water-quality guidelines (microbial, chemical and physical characteristics) for irrigation and processing fruits and vegetables
- The proper practices for monitoring water quality and disinfecting water used in irrigation and processing on the farm.

Equipment and materials needed:

- Laptop and LCD projector
- PowerPoint (PPT) presentation on CD
- Nametags, pens

Preparation needed:

- Review Module 6 and PPT prior to day of the workshop; become familiar with GAPs programming—how each module is an integral part of the other modules.
- Secure a laptop computer with PPT capability and an LCD projector. Save a copy of the presentation (from CD) on computer.
- Make copies of workshop activities, pre-test and post-test (if applicable) for all participants.
- Obtain, easels, flip charts, markers if needed.
- Prepare room to accommodate participants and projector. Prepare sign-in sheet and nametags, as applicable.

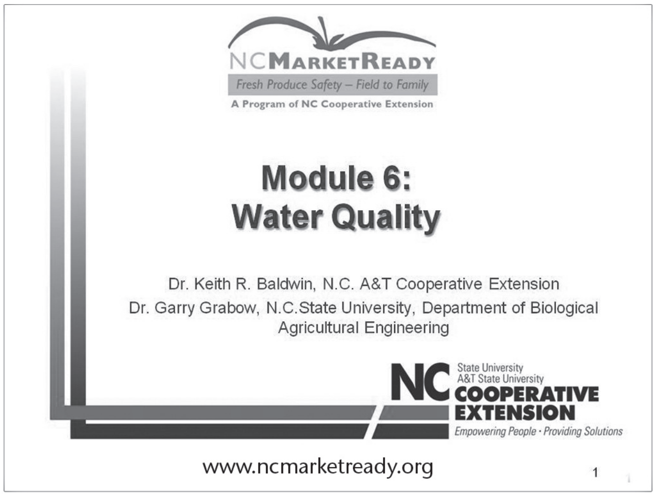
Module 6

Welcome

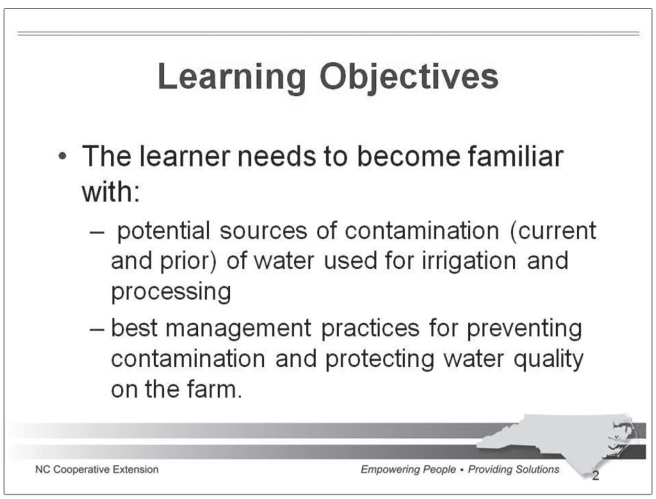
Have participants make nametags and introduce themselves.

PPT 6-1: Water Quality

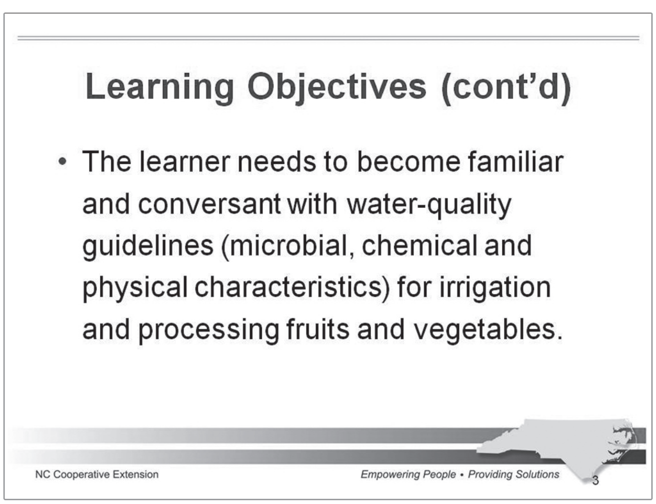
This module on water quality was developed by Dr. Keith R. Baldwin and Dr. Garry Grabow.

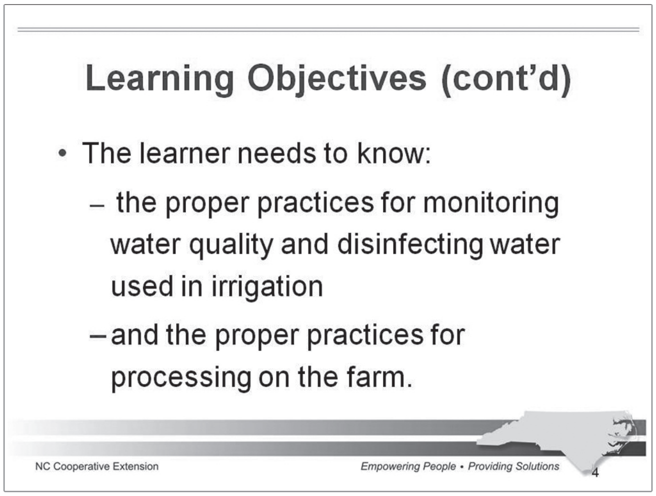


PPT 6-2: Learning Objectives

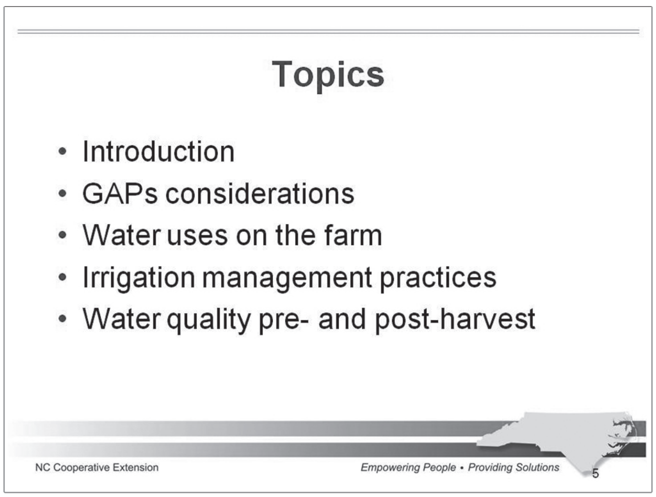


PPT 6-3: Learning Objectives (cont'd)



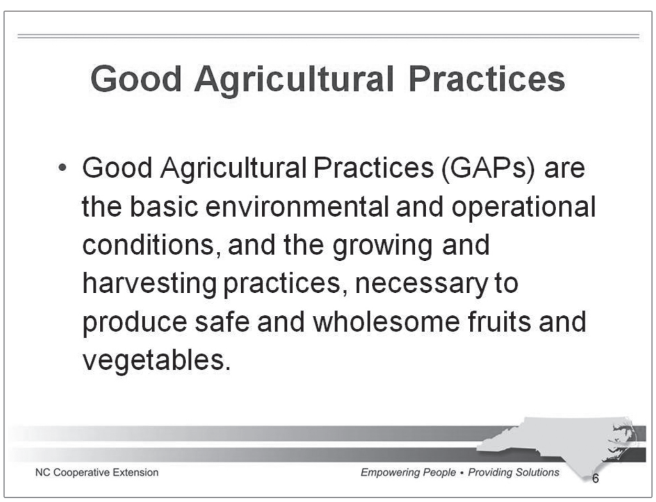


PPT 6-4: Learning Objectives (cont'd)

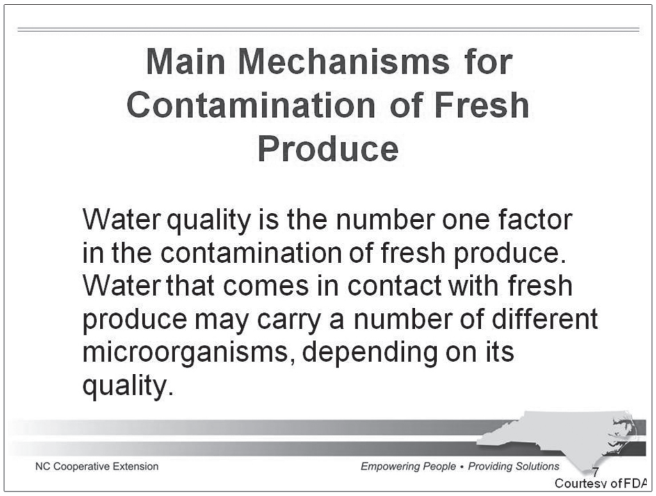


PPT 6-5: Topics

The material in this module can be broken down into five topics.

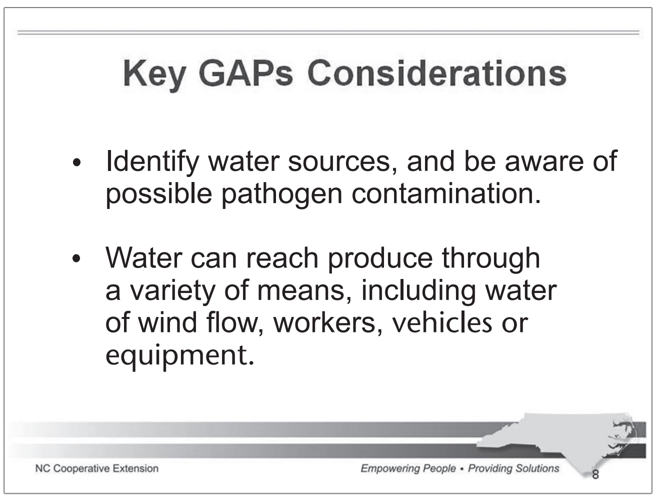


PPT 6-6: Good Agricultural Practices (GAPs)



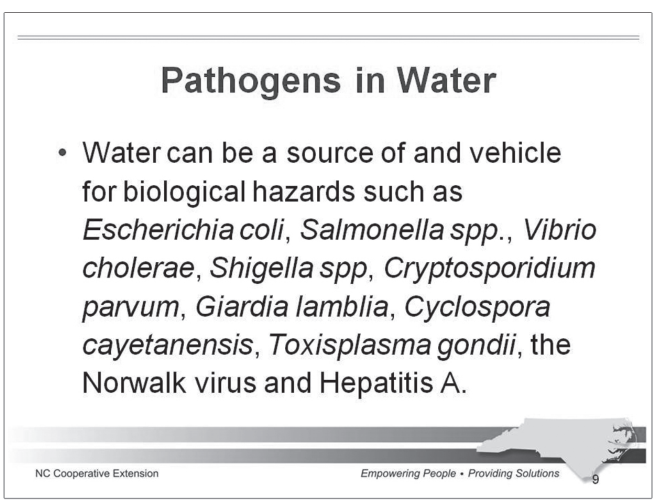
PPT 6-7: Mechanisms for Contamination of Fresh Produce

Water is an important means by which pathogens may contaminate fresh produce.



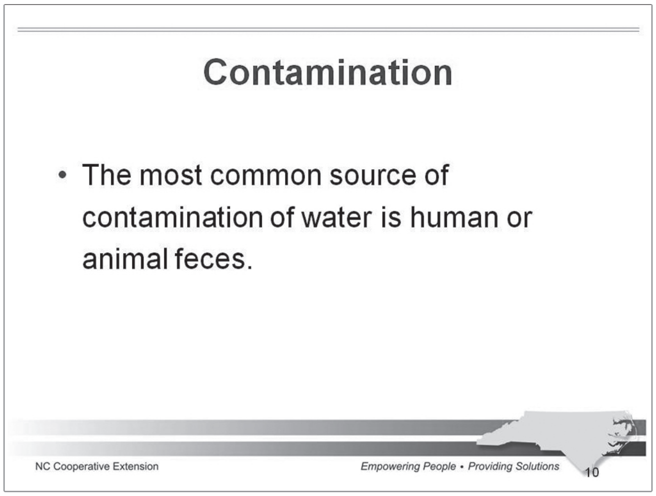
PPT 6-8: Key GAPs Considerations

Key overarching themes in building a fresh produce safety plan for the farm are listed here.



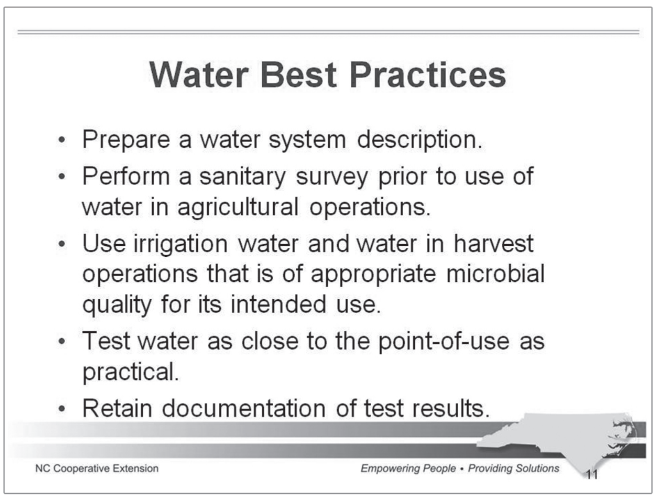
PPT 6-9: Pathogens in Water

Many human pathogens are readily transported in water. Microbial pathogens that cause human disease include *Escherichia coli*, *Salmonella spp.*, *Vibrio cholerae*, *Shigella spp.*, *Cryptosporidium parvum*, *Giardia lamblia*, *Cyclospora cayetanensis*, *Toxisplasma gondii*, the Norwalk virus and Hepatitis A.



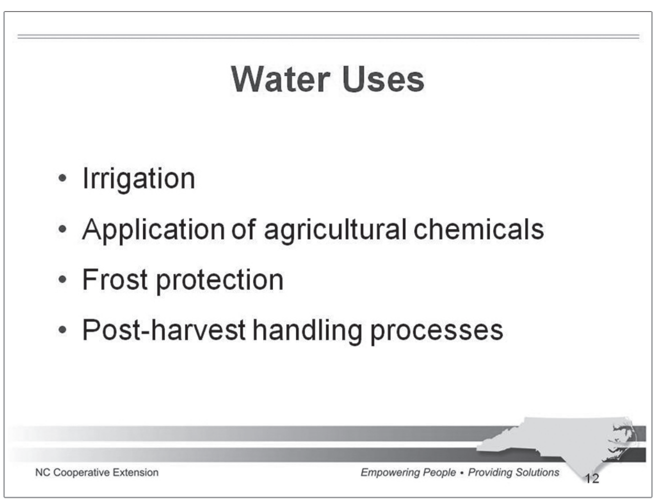
PPT 6-10: Contamination

The most common source of contamination of water is human or animal feces. Personal hygiene is critically important for preventing the spread of pathogens. Make sure employees always wash their hands after using restroom facilities. Livestock should not have access to irrigation water supplies as their manure can contaminate it.



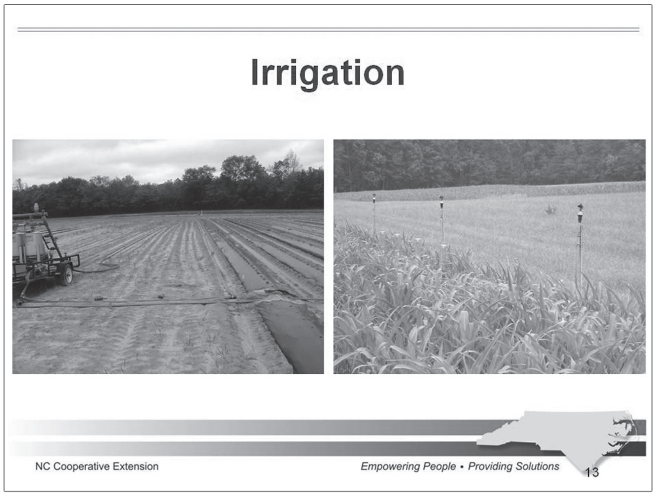
PPT 6-11: Water Best Practices

Assessing water quality on the farm begins with a thorough description of the water resources available for irrigating crops and washing produce during post-harvest handling. Maps and other schematics and written records documenting potential sources for contamination complement regular testing to demonstrate a comprehensive program to ensure water quality appropriate for its intended use.



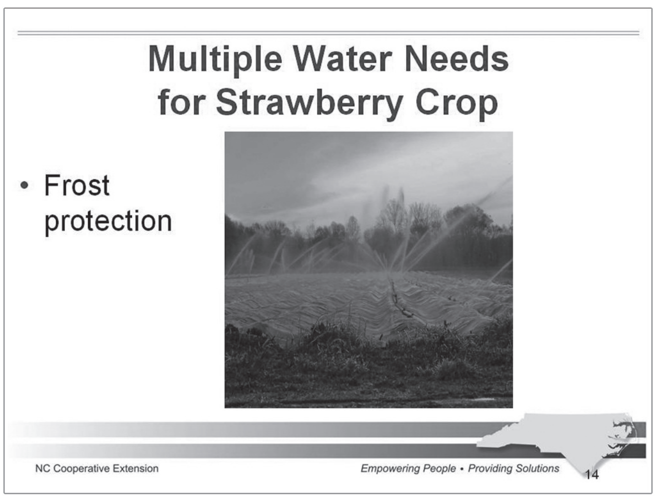
PPT 6-12: Water Uses

Water uses on the farm include:



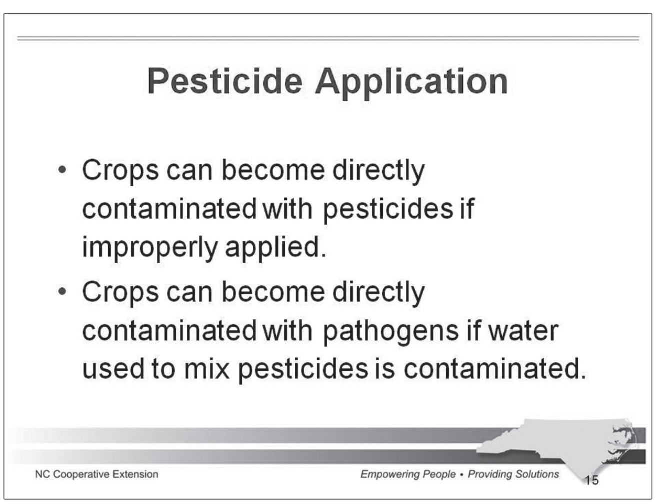
PPT 6-13: Irrigation

Rather than relying on rainfall to meet crop water requirements, most growers supply water to crops on a regular basis by irrigating. Drip irrigation and overhead (sprinkler) irrigation are the most common means for irrigating fruit and vegetable crops in North Carolina.



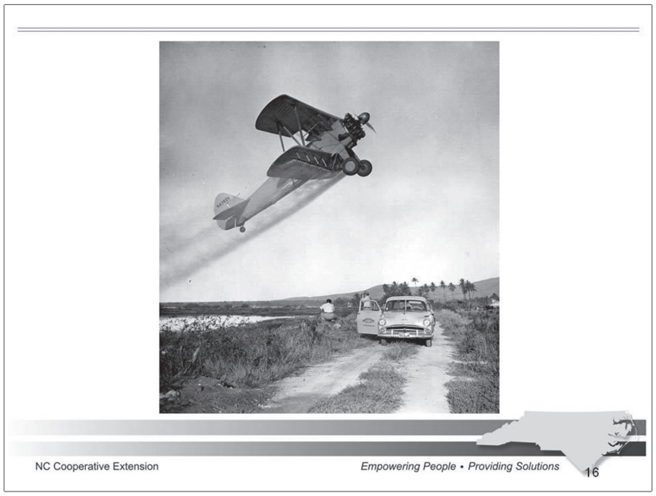
PPT 6-14: Multiple Water Needs for Strawberry Crop

Overhead irrigation is an effective means of protecting strawberry blossoms and maturing fruit from frost and freeze damage. However, ponds are the most common source of water for frost protection in North Carolina. There is considerable risk to pond water quality when livestock manure or runoff containing livestock manure contaminates ponds. Use water for frost protection that meets quality requirements for overhead irrigation of lettuce and leafy greens.



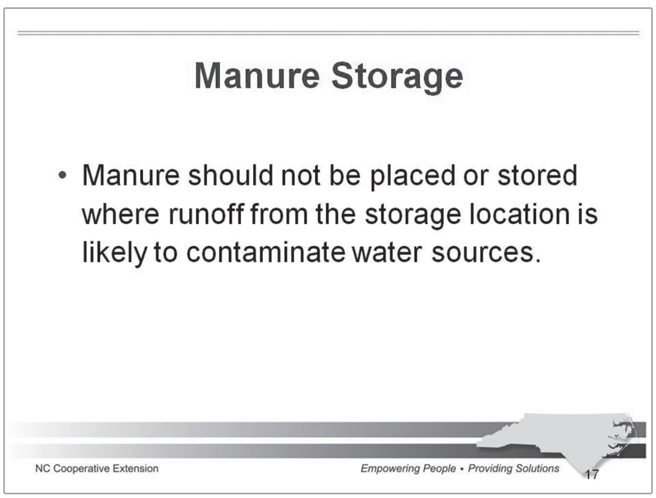
PPT 6-15: Pesticide Application

Crops can become directly contaminated with pesticides if improperly applied. Crops can become directly contaminated with pathogens if water used to mix pesticides is contaminated. Follow the directions on the pesticide label when applying pesticides to crops. Use the correct "rates" of application. Most pesticides have waiting periods after application before a crop can be harvested. Use potable water to mix pesticides in spray tanks.



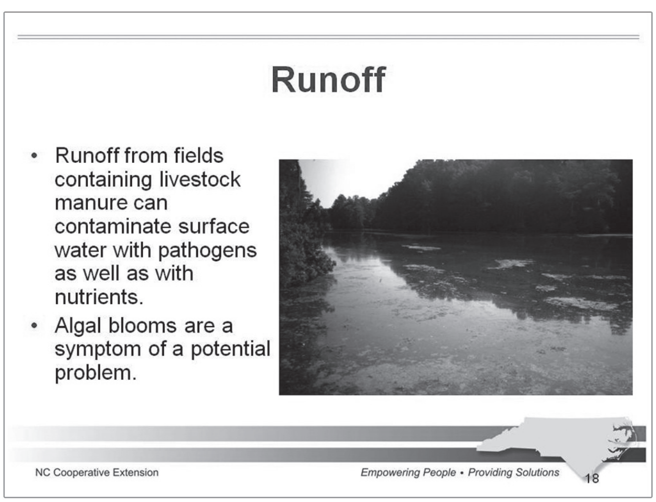
PPT 6-16: Using Pesticides Correctly

Pesticides are mixed with water and can be retained on the surfaces of produce when pesticides are applied to crops. Any pathogens in the water will be transferred to produce in the same way. Always follow directions on the pesticide label. Pesticides can only be used on crops that are identified on the label. There are limits for the amount of residual pesticide that may be retained on the produce at harvest. Use backflow prevention devices when filling pesticide tanks with water from municipal, surface or groundwater sources. Do not mix pesticides with water at wellheads. Crops, water and people are all at risk when pesticides are applied incorrectly.



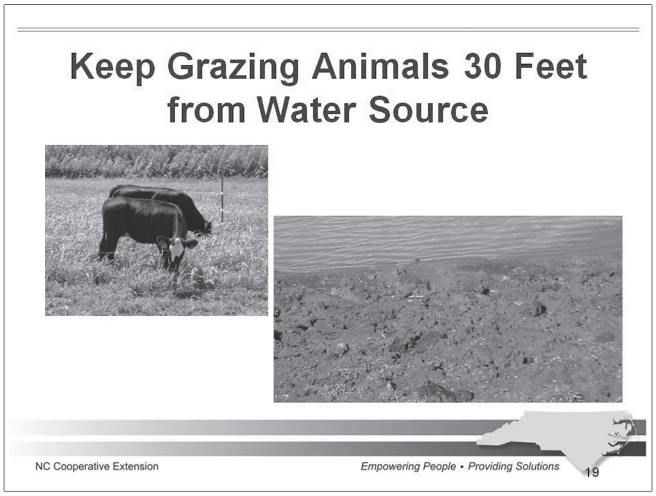
PPT 6-17: Manure Storage

Raw manure should not be placed or stored where runoff from the storage location is likely to contaminate water sources.



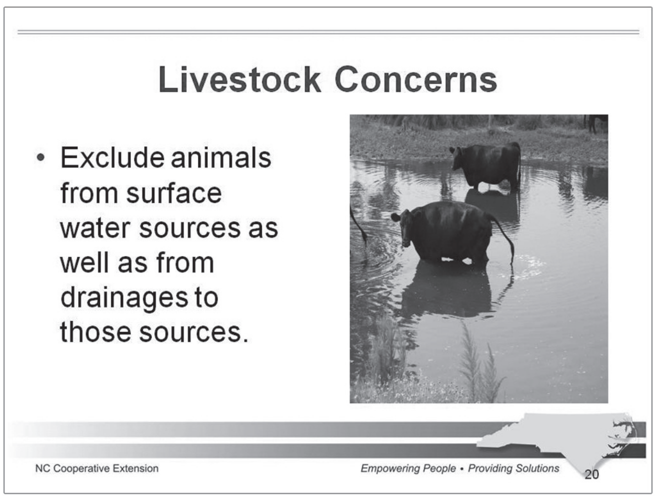
PPT 6-18: Runoff

Manure running off a farm field can not only contaminate water supplies with pathogens, but also with nutrients such as nitrogen and phosphorus. "Nutrient loading" of surface waters can result in algal blooms. Algal blooms can contribute to oxygen depletion in the water and lead to fish kills. Surface water supply sources that exhibit the symptoms shown in this can be assumed to be contaminated with pathogens.



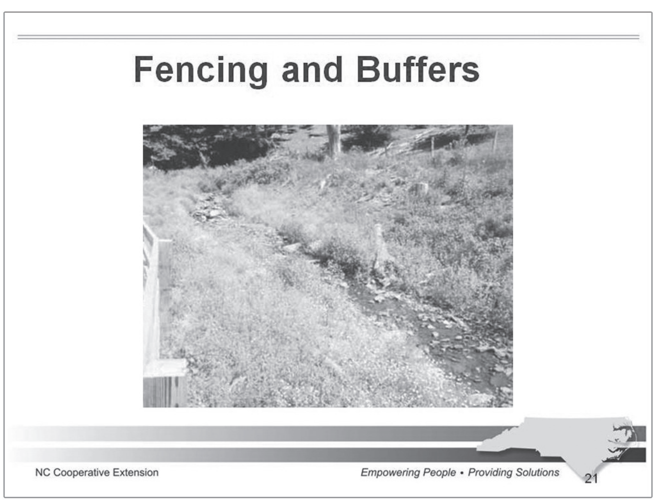
PPT 6-19: Keep Grazing Animals 30 Feet from Water Source

Water sources should not be near animal feedlots or other points where the movement of animal waste (runoff, wind dispersal) off-site, by any means, will contaminate the source. Growers should obtain records of wind and runoff (also seepage) patterns to check the potential for water moving from adjacent fields to water sources. Physical barriers such as fences, diversion berms or ditches should be constructed to prevent runoff. Animals should be excluded from irrigation ponds and other surface water used to irrigate fruit and vegetable crops.



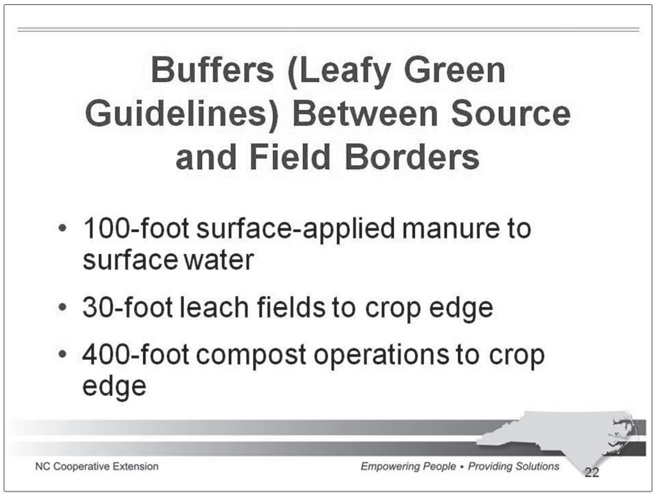
PPT 6-20: Livestock Concerns

Animals should be excluded from entering surface water sources as well as drainages to those sources. Animals are commonly excluded with fencing, and a vegetated buffer should be maintained around the perimeter of the water source. Where surface water serves as a source for watering livestock, water should be pumped to a site where watering will pose no significant risk to surface water quality. The Natural Resource Conservation Service EQIP cost-share program is available to farmers who want to mitigate threats to water quality.



PPT 6-21: Fencing and Buffers

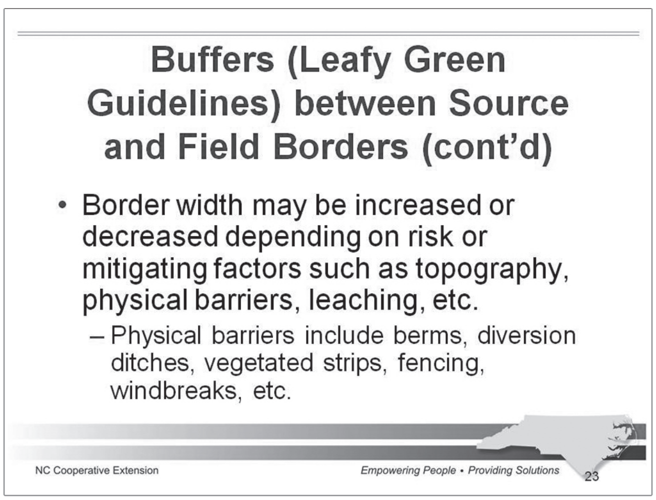
Surface waters should be fenced to keep livestock out of the water. There should be at least a 25-foot buffer between fencing and water. The buffer will serve as both a biofilter to physically trap sediment and potential contaminants, and as a vegetative sink for nutrients contained in any runoff to the water.



PPT 6-22: Buffers (Leafy Green Guidelines) between Source and Field Borders

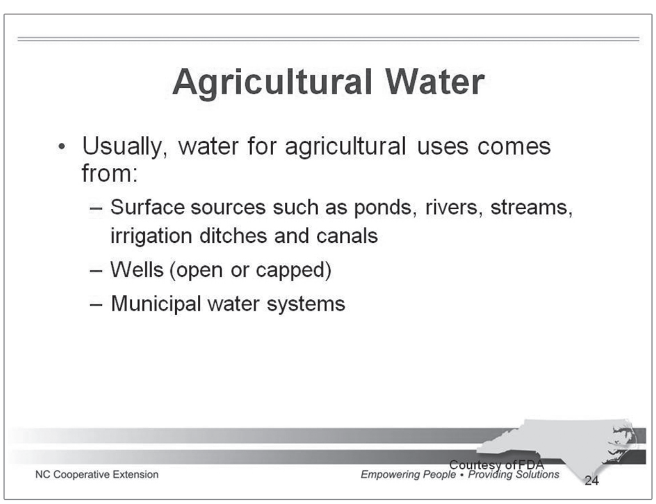
The distances shown in this slide are based on the best professional judgment of the authors of this presentation, as well as that of contributors and expert reviewers. These buffers should prevent potential cross-contamination from adjacent land uses, taking into consideration the 200-foot distance cited in the U.S. Food and Drug Administration (FDA) for separation of manure from wellheads and the 30-foot turn-around distance for production equipment.

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



PPT 6-23: Buffers (Leafy Green Guidelines) between Source and Field Borders (cont'd)

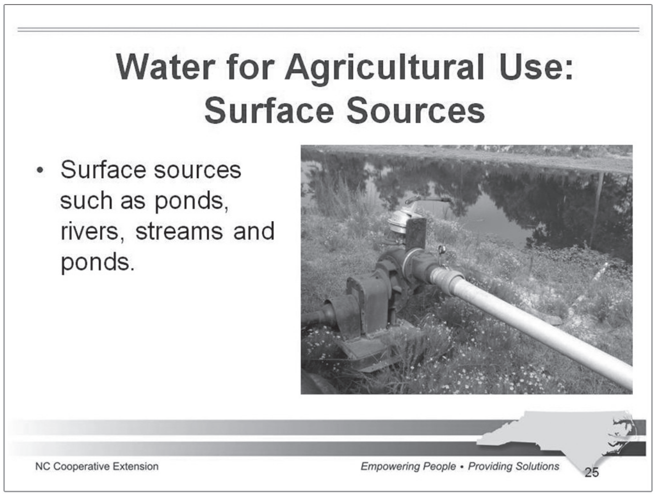
A hazard analysis should take into consideration any factors that may increase or decrease buffering needs. Border width may be increased or decreased depending on risk or mitigating factors such as topography, physical barriers, leaching, etc. Physical barriers include berms, diversion ditches, vegetated strips, fencing, windbreaks, etc.



PPT 6-24: Agricultural Water

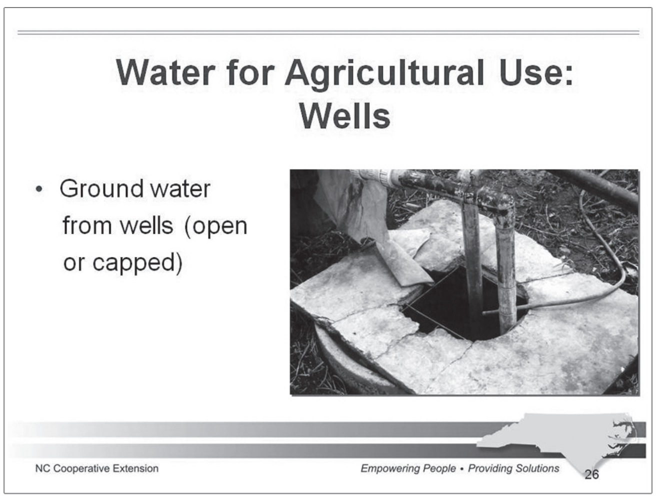
There are three main sources of agricultural water:

- Surface sources such as ponds, rivers, streams, irrigation ditches and canals
- Wells (open or capped)
- Municipal water systems.



PPT 6-25: Water for Agricultural Use

Throughout North Carolina, most irrigation water comes from surface impoundments, typically ponds. Ponds can easily become contaminated if livestock or wild animals are permitted access to the water.



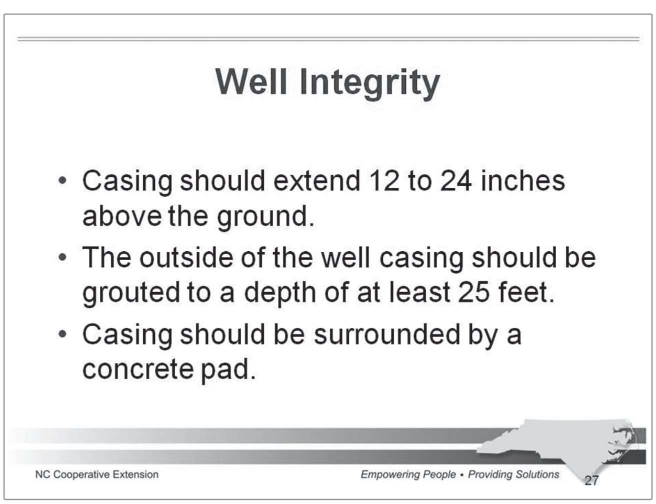
PPT 6-26: Water for Agricultural Use (cont'd)

In eastern North Carolina, some wells have sufficient capacity to irrigate using sprinklers. However, in most cases, wells are more appropriate for drip irrigation. The wellhead is a place where the risk of potential contamination is high. An improperly constructed well, like this one, provides a point source for contaminants to enter.

A well is constructed of a casing and a well cap. The casing is a pipe made of steel or plastic that gives firm structure to the hole dug for the well. The space between the casing and the soil around the hole should be sealed with grout as an extra

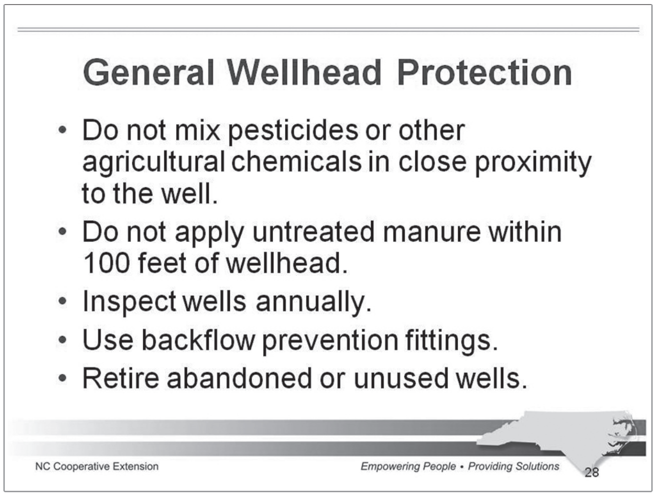
PPT 6-26 (continued)

protective barrier between the well and possible contaminants. The well cap is a seal at the top of the well hole to keep contaminants from the surface. The well cap should fit firmly with screens over the vents. When inspecting the well, the sound of water running into the well is an indication of leaks in the well casing.



PPT 6-27: Well Integrity

Toxic substances can enter the well itself, if the wellhead or casing is damaged in any way, so it is important to maintain wells in good working order. Runoff should be diverted away from the wellhead; well casings should extend more than 12 inches above the land surface; the outside of the well casing should be grouted to a depth of at least 25 feet; and a concrete pad should surround the casing at the surface. A concrete pad encourages drainage away from the water source or well. It is also important to put as much distance as possible between the water source and potential contaminants: septic tanks, drain fields, chemical storage, gas tanks, manure piles, etc.



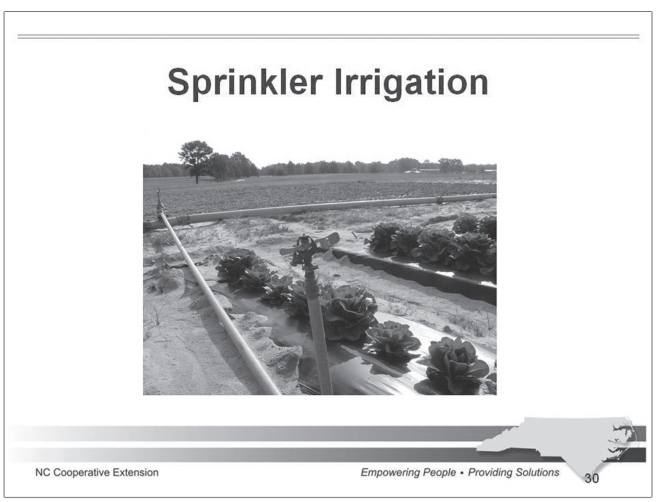
PPT 6-28: General Wellhead Protection

General best management practices for wellhead protection include:

- Do not mix pesticides or other agricultural chemicals in within 50 feet of the well.
- Do not apply untreated manure within 100 feet of the wellhead.
- Inspect wells annually.
- Use backflow prevention fittings.
- Retire abandoned or unused wells.
- Unused or wells that are inadequately maintained can provide a direct path for contaminants to enter groundwater sources. Hire a licensed, registered well driller or pump installer to retire wells that are not being used.

PPT 6-29: Water for Agricultural Use

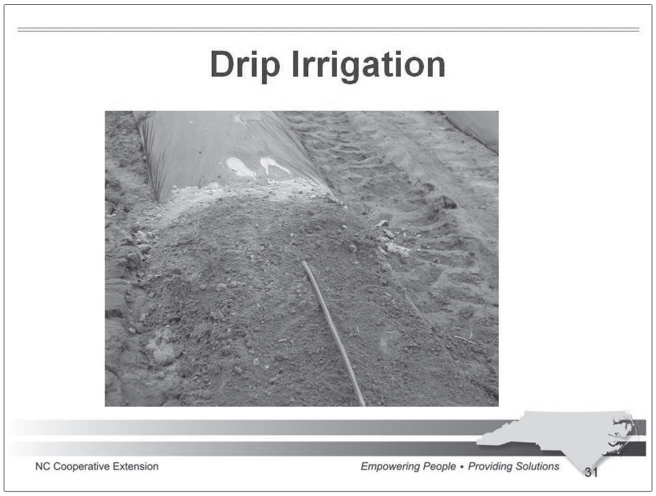
Irrigating crops with municipal water provides the lowest risk of produce contamination. However, using this water source is usually not feasible due to cost, field location and size. By law, water from public or municipal water systems must be potable. Growers should request a copy of water-quality test results annually. However, even public water purveyors can have episodic events resulting in microbially contaminated water. To be on the safe side, growers should test municipal water used for irrigation annually. The U.S. Environmental Protection Agency's (EPA) upper limit guidance is four parts per million (ppm) of residual chlorine in municipal water systems.



PPT 6-30: Sprinkler Irrigation

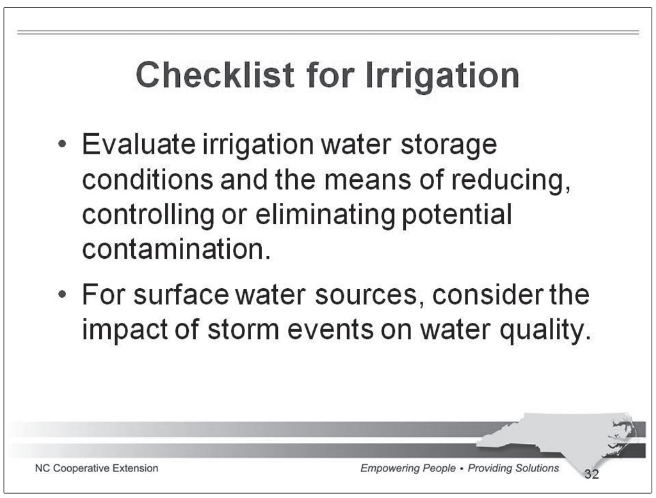
The quality of water, how and when it is used, and the characteristics of the crop affect produce safety risks. In general, the quality of water in direct contact with the edible portion of produce needs to be of better quality compared to uses where there is minimal contact.

Sprinkler irrigation practices (where the water drenches the crop) pose the most risk for causing contamination, especially if the water quality is unknown and the crop is near the harvest stage. When applying sprinkler irrigation, irrigate in the morning to maximize water use efficiency and reduce leaf-drying time. Rapid drying and ultraviolet light will reduce survival of both plant and human pathogens on crops.



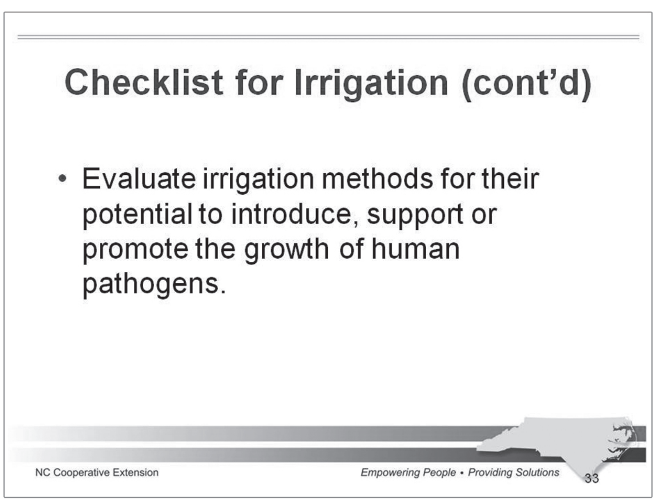
PPT 6-31: Drip Irrigation

Use drip irrigation whenever possible. Drip irrigation minimizes the risk of crop contamination because the edible parts of most crops are not wetted directly. Water is applied directly to the root zone, beneath both the plastic and the soil surface. The incidence of foliar diseases may also be reduced because many plant pathogens require wet leaf surfaces for infection. Water use efficiency is maximized, too.

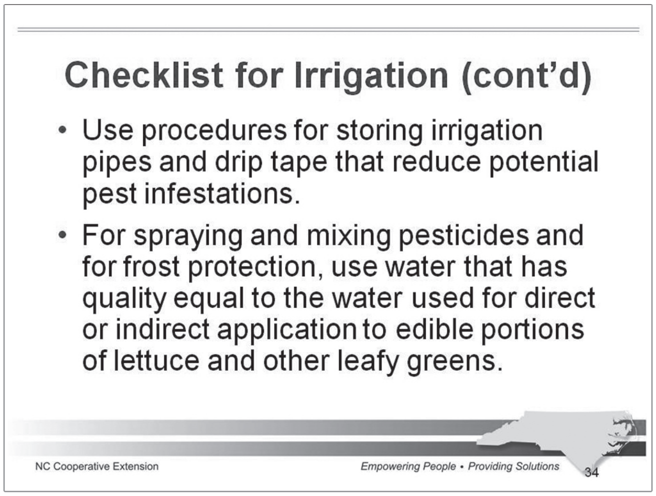


PPT 6-32: Checklist for Irrigation

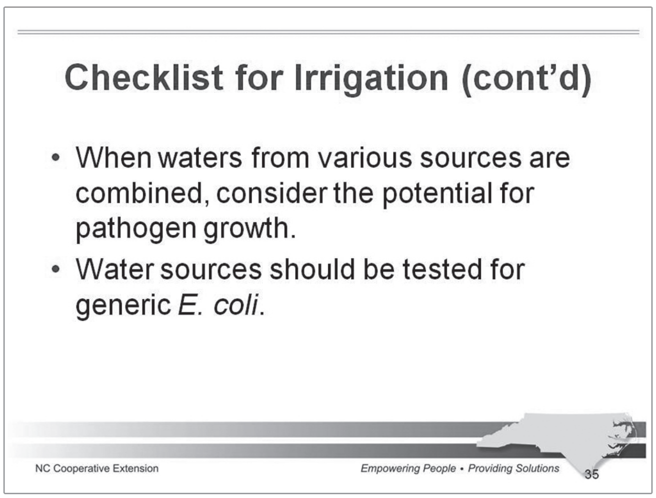
This slide and the two that follow outline some considerations for growers to think about as they plan an irrigation program that protects water quality:



PPT 6-33: Checklist for Irrigation (cont'd)



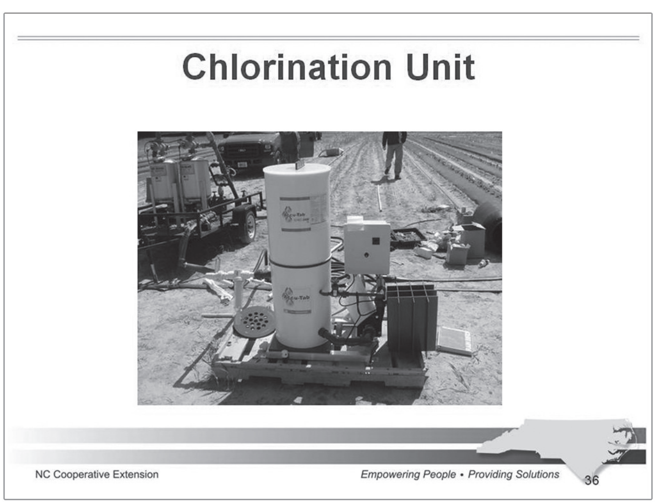
PPT 6-34: Checklist for Irrigation (cont'd)



PPT 6-35: Checklist for Irrigation (cont'd)

The prevailing consensus of opinion is that standard microbial testing of water for the presence of total coliform or fecal coliform bacteria provides a poor indication of the quality or safety of water for production or post-harvest handling of fruit and vegetable crops. Presence/absence tests or counts of generic *E. coli* in water or on fresh produce are also poor indicators of fecal contamination and worse predictors of pathogen presence, but they are the best tests we presently have.

A recent survey of laboratories in North Carolina providing microbiological testing services indicated that most labs charge about $25 for a generic *E. coli* test. Total and fecal coliform tests cost about the same.

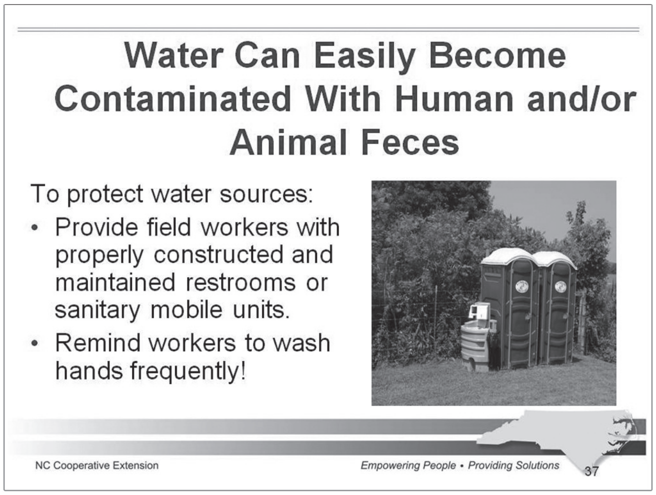


PPT 6-36: Chlorination Unit

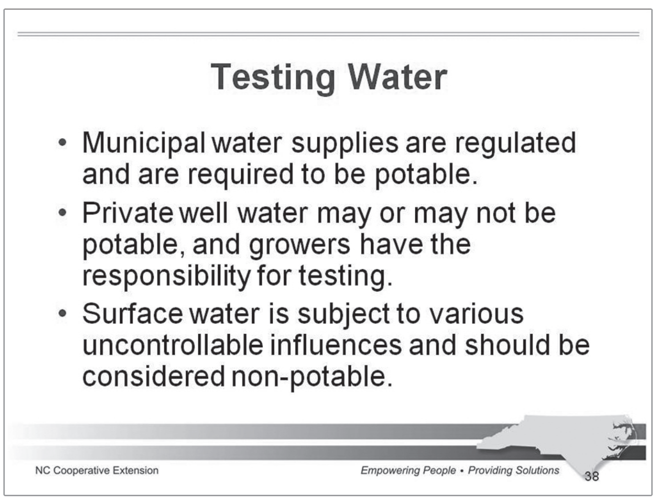
This is a unit which uses chlorine tablets. The tablets dissolve in water and are injected into the line downstream from the sand filters used to clean pond water (seen in background). It should be noted that the purpose of chlorine injection is to maintain "available" chlorine concentration in the irrigation water at the desired level. In the not-too-distant future, treatment of irrigation water may be required.

The unit should supply available chlorine at concentrations high enough to maintain an available chlorine concentration of approximately 4 ppm at the end of the "line." The concentration

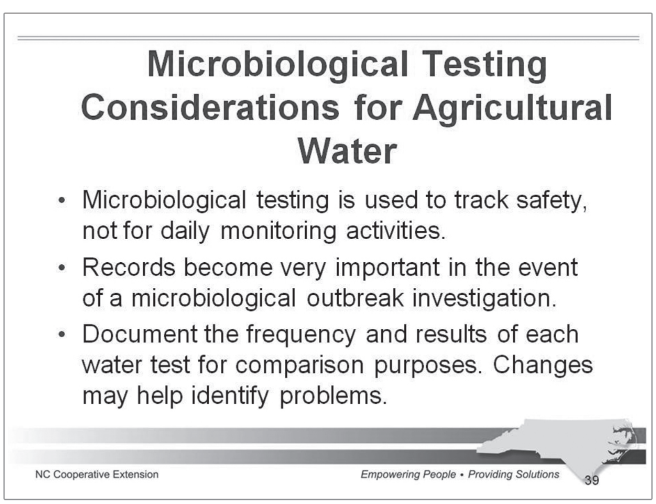
PPT 6-36 (continued)
at the head of the system will probably have to be higher, but the exact level is a matter of trial and error. It is based upon the organic load of the water and pH (the chlorine demand equals input chlorine minus available chlorine at the end of the system).



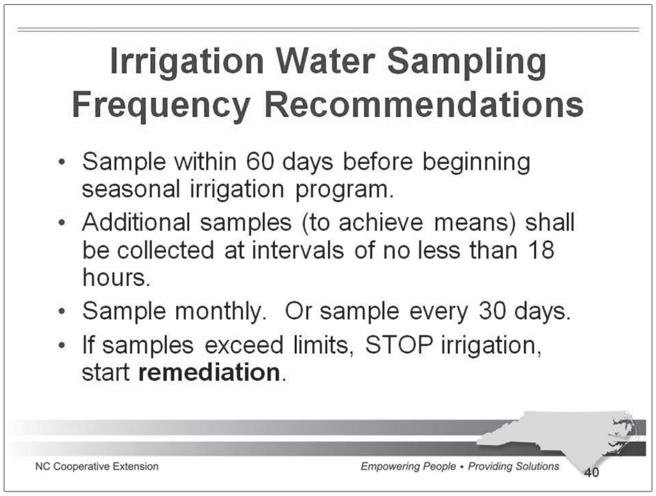
PPT 6-37: Water Can Easily Become Contaminated With Human and/or Animal Feces.
One of the primary pathways for produce contamination is handling the produce without thoroughly washing hands after visiting the restroom.



PPT 6-38: Testing Water
Producers are required to test water used for irrigation and processing. Accurate records are important.

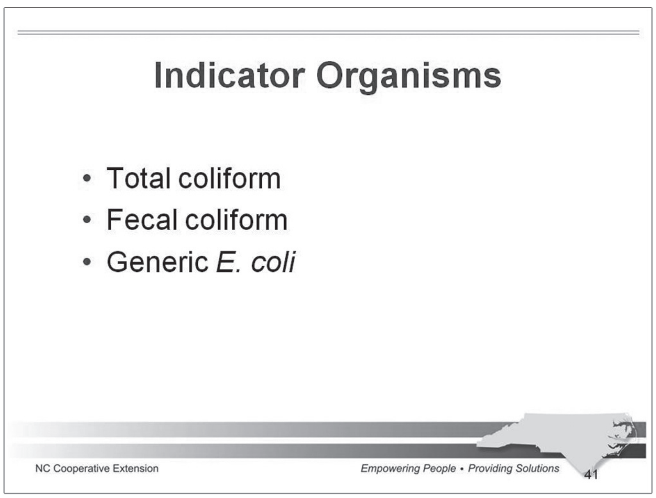


PPT 6-39: Microbiological Testing Considerations for Agricultural Water



PPT 6-40: Irrigation Water Sampling Frequency Recommendations

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



PPT 6-41: Indicator Organisms

Three common indicator organisms used to test for fecal contamination of water are *total coliform, fecal coliform* and generic *E. coli*. The prevailing consensus of opinion is that standard microbial testing of water for the presence of total coliform or fecal coliform bacteria provides a poor indication of the quality or safety of water for production or post-harvest handling of fruit and vegetable crops. Presence/absence tests or counts of generic *E. coli* in water or on fresh produce are also poor indicators of fecal contamination and worse predictors of pathogen presence, but they are the best tests we presently have.

PPT 6-41 (continued)

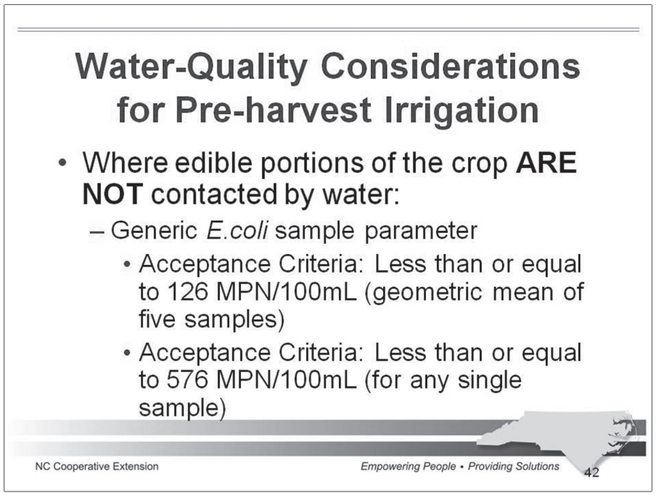
Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental. Fecal contamination is not likely. However, if environmental contamination can enter the system, there may also be a way for pathogens to enter the system. Therefore, it is important to find the source and resolve the problem.

Fecal coliform bacteria are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination, meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected.

E. coli is a sub-group of the fecal coliform group. Most *E. coli* bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. Some strains, however, can cause illness. The presence of *E. coli* in a drinking water sample almost always indicates recent fecal contamination, meaning there is a greater risk that pathogens are present.

A note about *E. coli*: *E. coli* outbreaks receive much media coverage. Most outbreaks have been caused by a specific strain of *E. coli* bacteria known as *E. coli* O157:H7. When a drinking water sample is reported as "*E. coli* present" it does not mean that this dangerous strain is present and, in fact, it is probably not present. However, it does indicate recent fecal contamination. Boiling or treating contaminated drinking water with a disinfectant destroys all forms of *E. coli*, including O157:H7.

Source: http://www.doh.wa.gov/ehp/dw/programs/coliform.htm



PPT 6-42: Water-Quality Considerations for Pre-harvest Irrigation

These criteria for generic *E.coli* are taken from the Leafy Greens Marketing Agreement (non-foliar) and are derived from EPA recreational water standards:

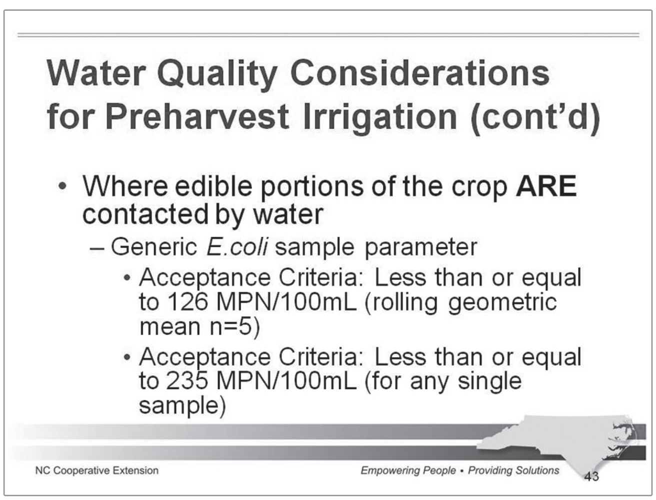
MPN = Most probable number per 100 ml of sample. (CFU= Colony-forming units is another way to quantify samples.) MPN and CFU are both expressed as counts of colony-forming units per 100 ml and are numerically equivalent to one another. The MPN method uses statistical probability to infer the colony counts.

PPT 6-42 (continued)

Bacteria counts are oftentimes expressed in logarithmic units since the values can be extremely high. A geometric mean is calculated by taking the log of the counts, then computing the average of the log transformed values, and finally back-transforming the average of the log values to the linear scale by taking the anti-log. The geometric mean will normally be less than the arithmetic mean (the mean calculated with untransformed count values) as it serves to lessen the impact of high values.

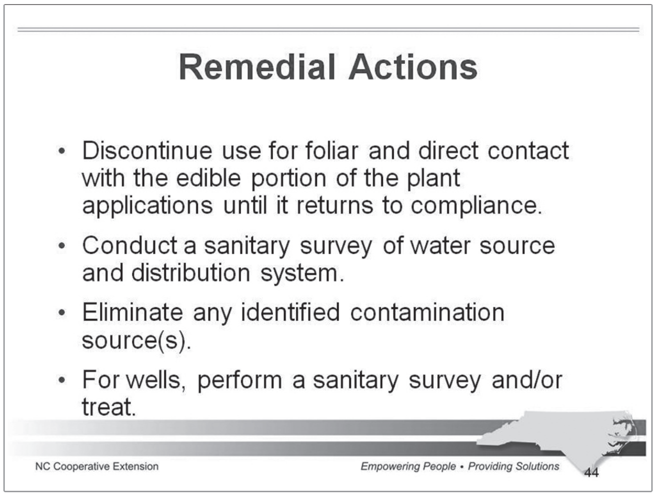
Note: Geometric mean, or Geomean, is a function in Microsoft Excel.

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



PPT 6-43: Water-Quality Considerations Pre-harvest Irrigation (cont'd)

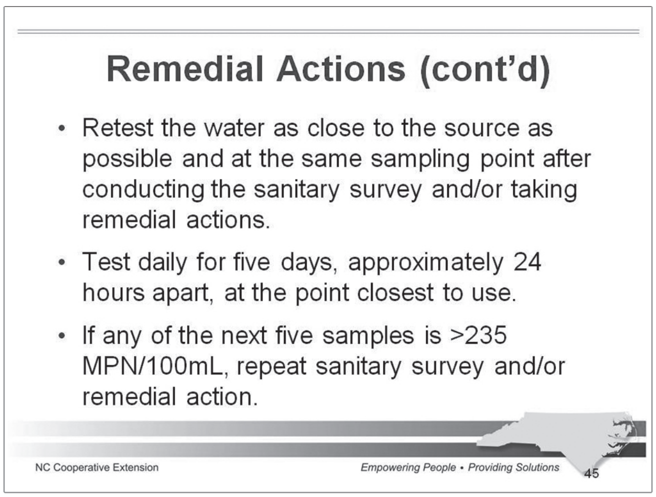
These criteria for generic *E.coli* are taken from the Leafy Greens Marketing Agreement (foliar) and are derived from EPA recreational water standards.



PPT 6-44: Remedial Actions

If the water sample from the system does not meet acceptance criteria in either of the last two cases:

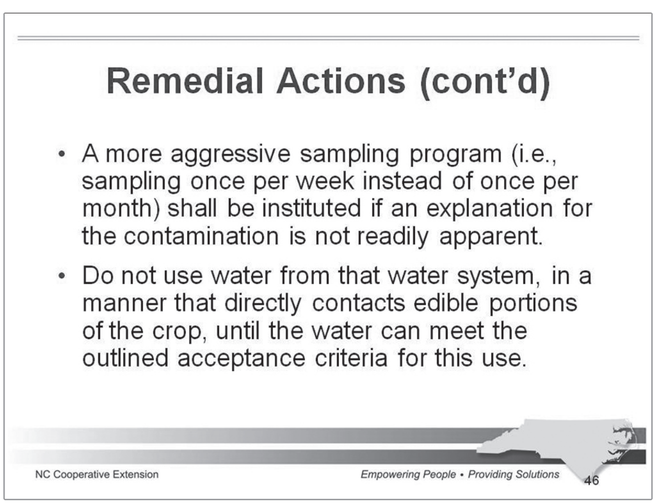
Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



PPT 6-45: Remedial Actions (cont'd)

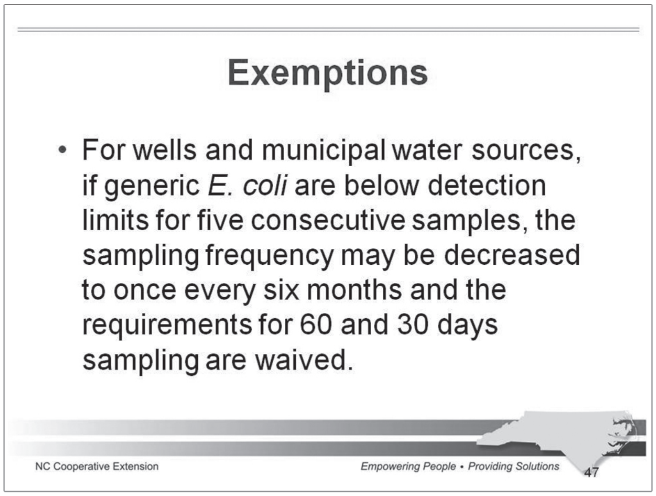
Retest the water after conducting the sanitary survey and/or taking remedial actions to determine if it meets the outlined microbial acceptance criteria for this use. This sample should represent the conditions of the original water system. If feasible, this test should be performed as close as practical to the original sampling point. Retest the water at the same sampling point after conducting the sanitary survey and/or taking remedial actions. Test daily for five days, approximately 24 hours apart, at the point closest to use. If any of the next five samples is >235 MPN/100mL, repeat the sanitary survey and/or remedial action.

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



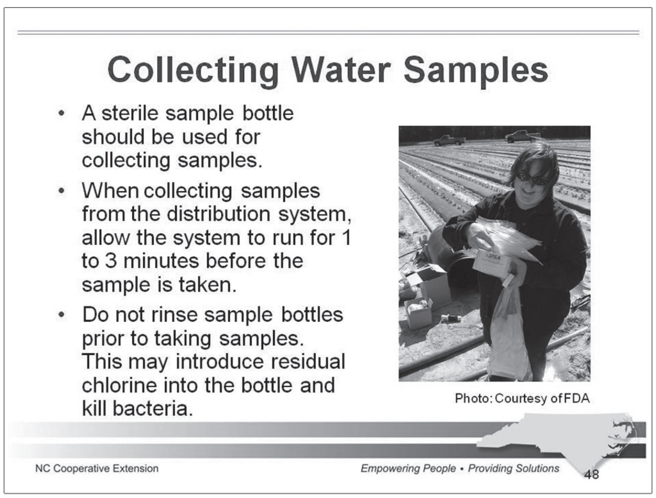
PPT 6-46: Remedial Actions (cont'd)

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



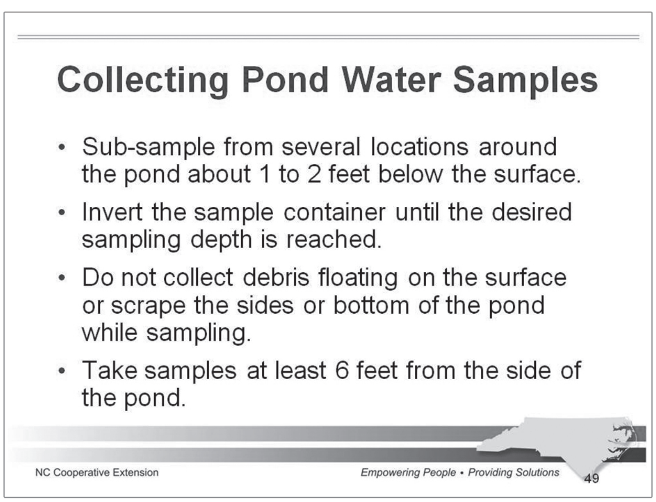
PPT 6-47: Exemptions

For wells and municipal water sources, if generic *E. coli* are below detection limits for five consecutive samples, the sampling frequency may be decreased to once every six months and the requirements for 60- and 30-day sampling are waived.



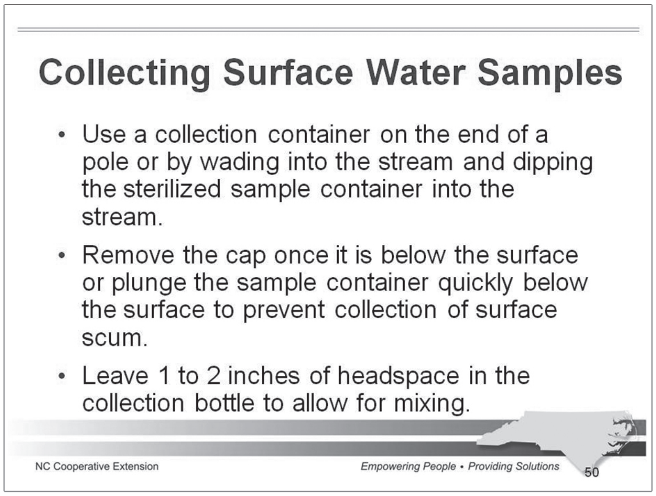
PPT 6-48: Collecting Water Samples

No notes.



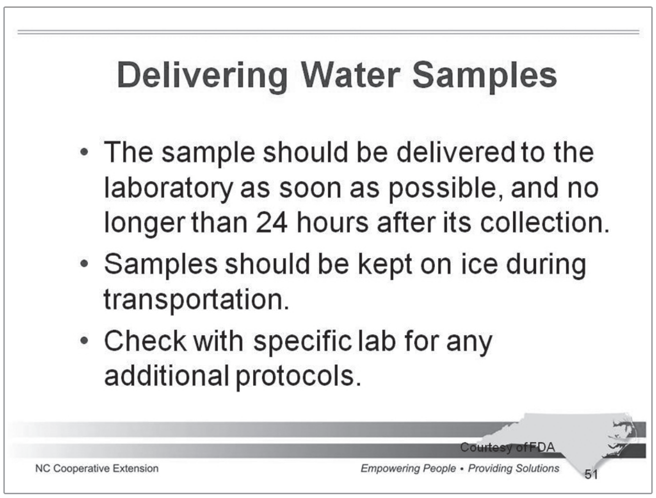
PPT 6-49: Collecting Pond Water Samples

Ponds are the most common sources of irrigation water in North Carolina. To take a representative sample, several subsamples should be taken and combined into one sample. Subsample from several locations around the pond about 1 to 2 feet below the surface. To prevent water at the surface from entering the sampling container, invert it until the desired sampling depth is reached. Do not collect debris floating on the surface or scrape the sides or bottom of the pond while sampling. Take samples at least 6 feet from the side of the pond. A telescoping rod with a quart container at the end makes for easy sampling.



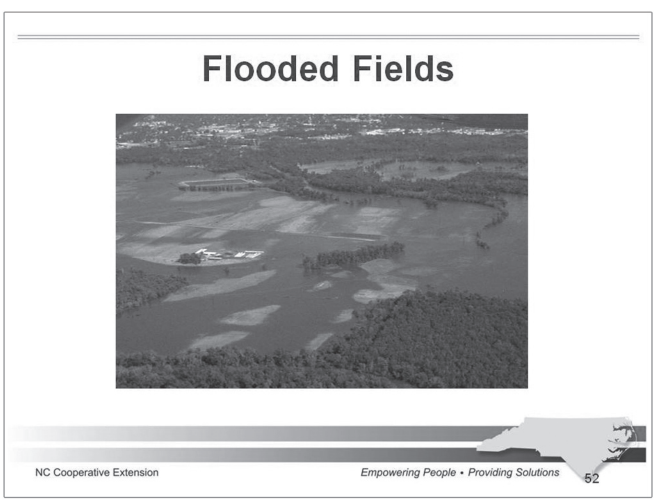
PPT 6-50: Collecting Surface Water Samples

Samples from rivers and streams may be collected using a collection container on the end of a pole as with pond sampling, or by wading into the stream and dipping the sterilized sample container into the stream. Either remove the cap once it is below the surface, or plunge the sample container quickly below the surface to prevent collection of surface scum. Leave 1 to 2 inches of headspace in the collection bottle to allow for mixing. Be sure to use a personal flotation device (lifejacket) when near or in a stream.



PPT 6-51: Delivering Water Samples

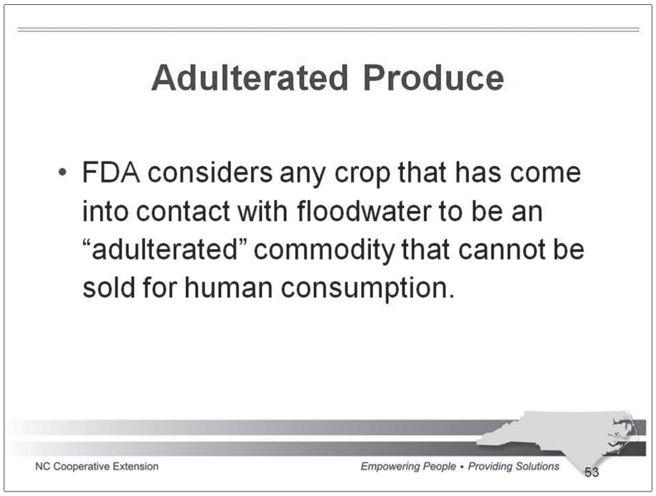
Transfer at least 100 ml of the composite sample into a sterile sample container, place on ice in a cooler and deliver to a lab within six hours if possible and always within 24 hours. Obtain chain of custody forms from the lab or create them. These forms show who took the sample, when sampling occurred, and when samples were delivered to the laboratory. Many labs will not be open on the weekend so plan sampling around laboratory hours.



PPT 6-52: Flooding

Because wastewater contains high levels of pathogenic microorganisms, principal health risks to humans from flooding are consumption of crops grown in fecally contaminated soil and ingestion of contaminated water. Flood waters polluted with microbial and other contaminants also may be detrimental to the health of livestock and plant crops.

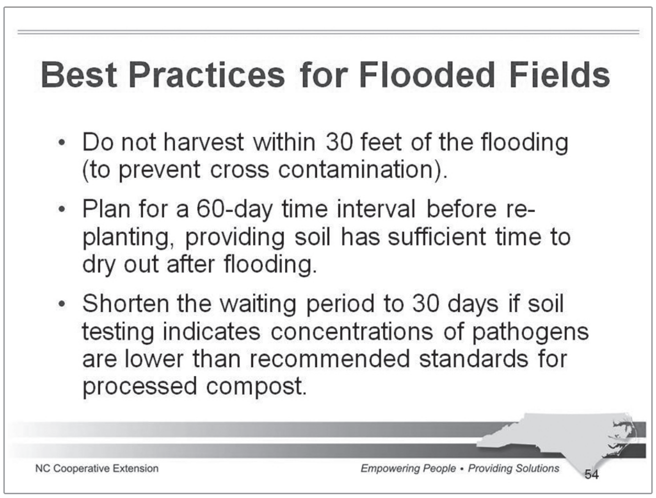
This image shows flooding at the Center for Environmental Farming Systems caused by Hurricane Floyd.



PPT 6-53: Adulterated Produce

Adulterated food may be subject to seizure under the Federal Food, Drug, and Cosmetic Act, and those responsible for its introduction or delivery for introduction into interstate commerce may be enjoined from continuing to do so or prosecuted for having done so. Food produced under unsanitary conditions whereby it may be rendered injurious to health is adulterated under § 402(a)(4) of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 342(a) (4)).

FDA considers any crop that has come into contact with floodwater to be an "adulterated" commodity that cannot be sold for human consumption.



PPT 6-54: Best Practices for Flooded Fields

EPA's pathogen equivalency standards are described at: http://www.epa.gov/nrmrl/pec/basic.html.

Considerations Before Planting Fields That Have Been Recently Flooded Include:

- Assess the time interval between the flooding event, crop planting and crop harvest. Comparative soil samples may be utilized to assess relative risk if significant reductions in indicator microorganisms have occurred within this time interval.

PPT 6-54 (continued)

- Determine the source of flood waters (drainage canal, river, irrigation canal, etc.) as to whether there are significant upstream potential contributors of human pathogens at levels that pose a significant threat to human health.
- Allow soils to dry sufficiently and be reworked prior to planting subsequent crops on formerly flooded production ground.
- Sample previously flooded soil for the presence of microorganisms of significant public health concern or appropriate indicator microorganisms. Microbial soil sampling can provide valuable information regarding relative risks; however, sampling by itself does not guarantee that all raw agricultural commodities grown within the formerly flooded production area are free of the presence of human pathogens.

The best practices for produce in proximity to a flooded area but not contacted by flood water are:

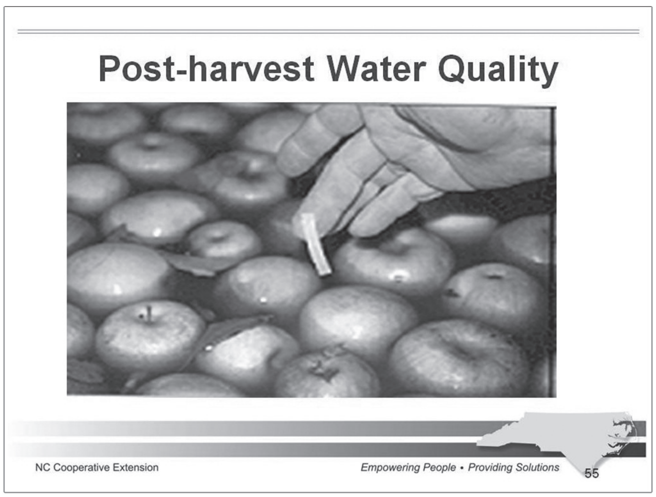
- Prevent cross contamination between flooded and non-flooded areas. This can be accomplished by cleaning equipment and preventing any farming, harvesting equipment or personnel from coming into contact with the flooded area during growing and harvesting activities in non-flooded areas.
- Place markers identifying both the high-water line and an interval 30 feet beyond this line to make sure produce is not contaminated or adulterated. If 30 feet is not sufficient to prevent cross

PPT 6-54 (continued)

contamination while turning harvesting or other farm equipment in the field, use a greater appropriate interval.

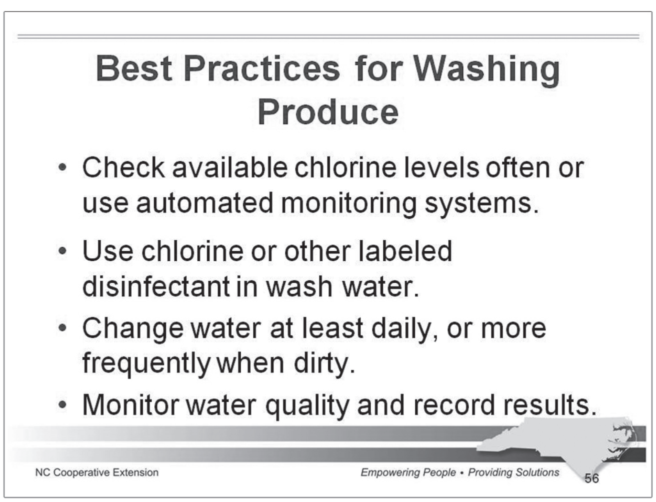
- Take photographs of the area for documentation.
- Do not harvest produce within the 30-foot buffer zone.
- Data presented in a study conducted by Casteel et al. (2006) showed that a microorganism commonly present in soil, *Clostridium perfringens,* is useful for comparing relative levels of fecal contamination in soil. Sampling for this organism is useful in "before/after" situations. The authors of this journal article found that the relatively low levels of *E. coli* in soil suggest that it is less suitable for comparing the relative levels of fecal contamination of soil, either as a result of flooding or by some other means.

Source: Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576



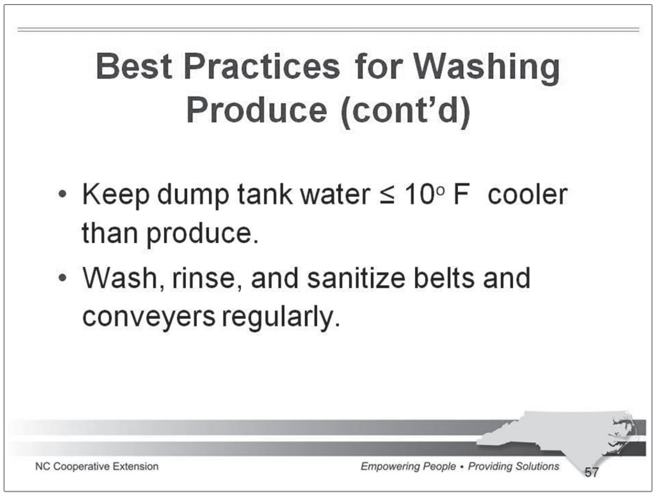
PPT 6-55: Post-harvest Water Quality

Perhaps the most critical step in handling fresh produce is washing it in high-quality water.



PPT 6-56: Best Practices for Washing Produce

Available chlorine is also sometimes referred to as "free chlorine." In layman's terms, these two are equivalent.



PPT 6-57: Best Practices for Washing Produce (cont'd)

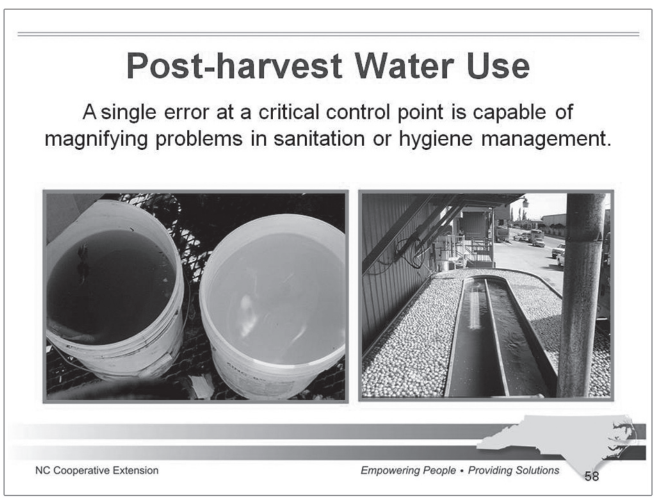
Temperature gradients between dump tank and field fruit can occur that can increase transmission of pathogens across fruit surface.

Wash water in flumes and dump tanks should be slightly warmer (suggested 10° F) than the produce. This minimizes the uptake of water into the produce. Water should be changed when it gets dirty or after several hours of operation, and no less frequently than daily.

For produce that will be in the dump tank water for more than 30 seconds, heat the dump tank

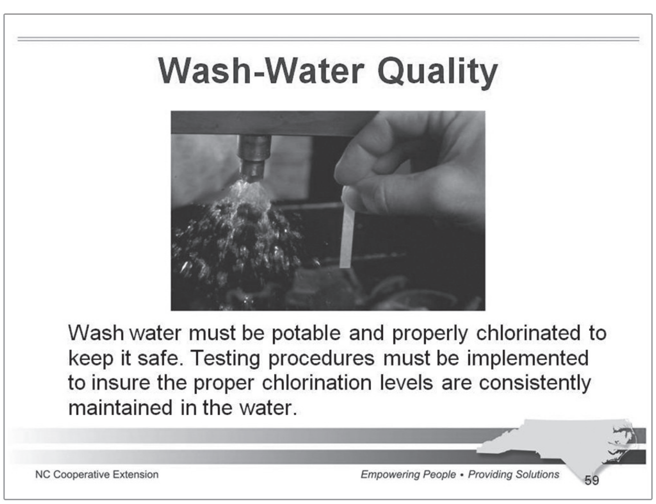
PPT 6-57 (continued)

water to about 10° F above the incoming fruit pulp temperature to prevent bacterial pathogens from infiltrating the produce. For more details concerning managing tomato dump tanks, see Ritenour et al. (2002- http://edis.ifas.ufl.edu/CH160) and Mahovic et al. (2004- http://edis.ifas.ufl.edu/HS131) .



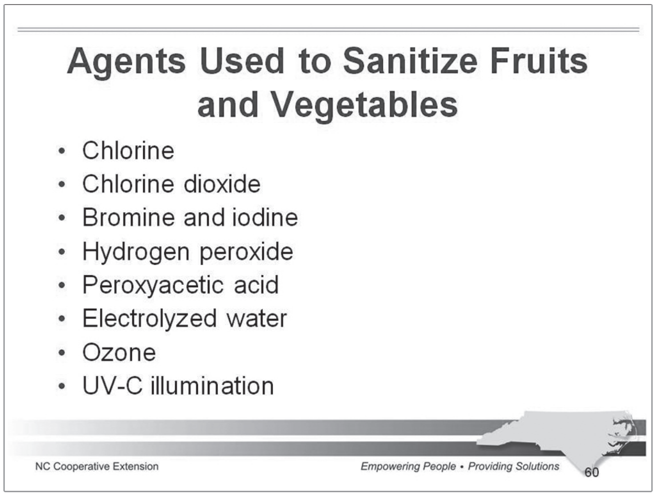
PPT 6-58: Post-harvest Water Use

If contamination occurs at a single critical point, the contamination can spread through the whole process stream. Photo at left shows turbid (dirty) water and relatively clean water. Photo on right is of a flume.



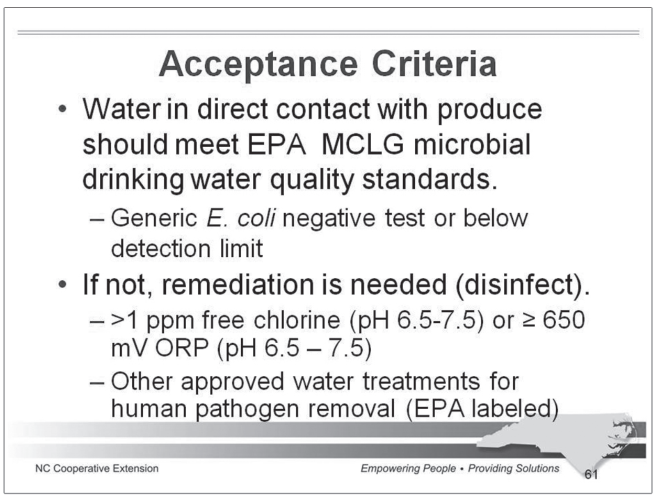
PPT 6-59: Wash-Water Quality

Potable water refers to water that is safe to drink. While the water used in post-harvest processing is not meant to be used as drinking water, it is recommended that water used in post-harvest processing start out at potable quality. After initial use (recycling), or if the water does not meet potable standards, disinfection of the water will be required. One common way of disinfecting water is by chlorination.



PPT 6-60: Agents Used to Sanitize Fruits and Vegetables

Many chemicals are used to sanitize fresh produce including chlorine, chlorine dioxide, bromine and iodine, hydrogen peroxide, peroxyacetic acid, electrolyzed water, ozone and UV-C (Ultraviolet) illumination.



PPT 6-61: Acceptance Criteria

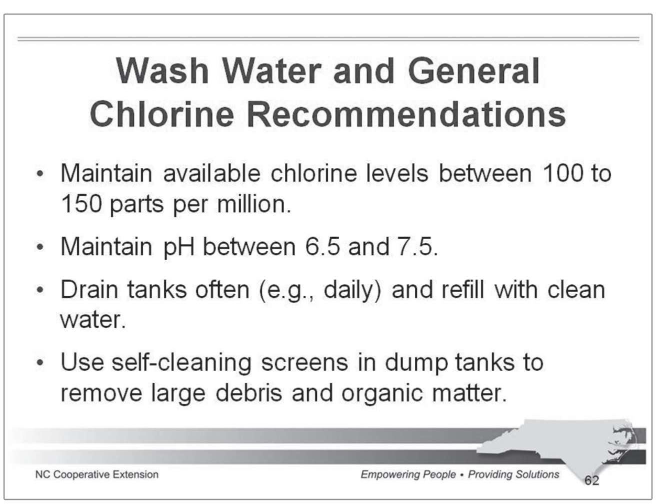
Generic *E. coli* testing guidance from the Leafy Greens Marketing Agreement. A generic *E. coli* test here can be presence or absence. Presence/absence tests simply test for the presence or absence of microbial indicator bacteria such as generic *E. coli*, while the tests required should indicate quantitative results. EPA's MCLG means "maximum contaminant level goal." The MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals. MCLs

PPT 6-61 (continued)

(or maximum contaminant levels) are enforceable standards. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration.

MCLG for total coliform in drinking water is zero.

An MCLG or MCL does not exist for agricultural water. However, growers are urged to minimize all hazards over which they have control.



PPT 6-62: Wash Water and General Chlorine Recommendations

So far we have seen that for effective sanitation we must keep chlorine concentrations between 100 and 150 ppm, the pH of solution between 6.5 and 7.5, and also keep organic matter out of water used in processing. Keeping the pH between 6.5 and 7.5 maximizes the disinfection action of chlorine. If the pH is over 7.5, the disinfection power is greatly reduced. Keeping organic matter out of processing water means that less chlorine will need to be added to achieve the desired available (free) chlorine levels.

Chlorination of Wash Water

Crop	Chlorine Strength (available chlorine), ppm	Process
Bell Peppers	300-400/150-200	Dump Tank/Sprayer belt
Melons	100-150	Dump Tank/Sprayer
Lettuce, cabbage, leafy greens	100-150	Sprayer belt / Hydrocooler
Potatoes	200-300/100-200	Flume/Sprayer belt
Tomatoes		

Source: Post-harvest Chlorination , Trevor Suslow UC Davis

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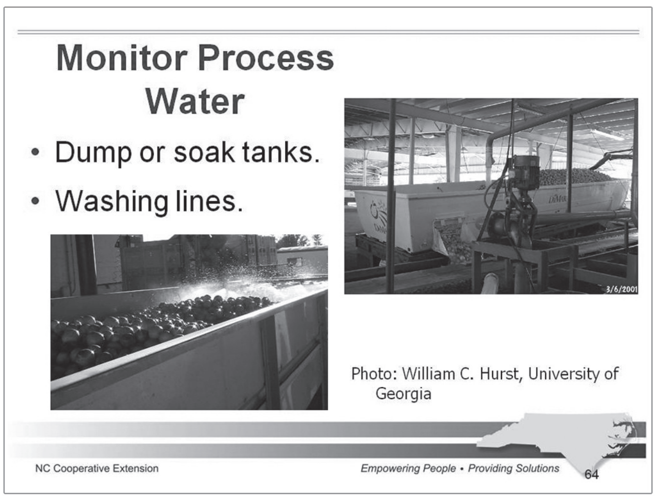
PPT 6-63: Chlorination of Wash Water

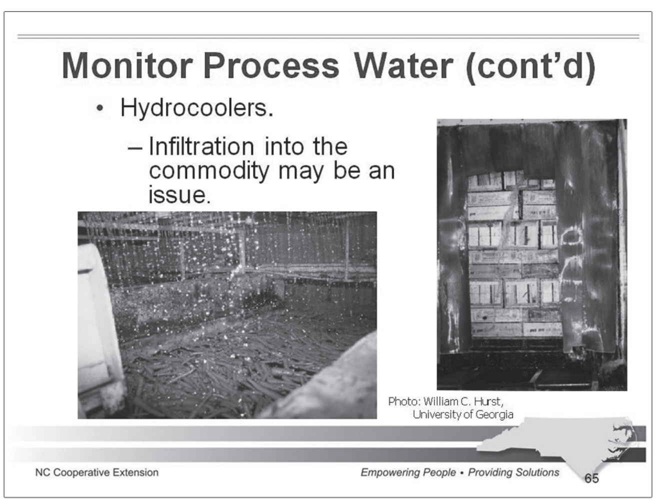
Recommended chlorine levels in process water at various points in the post-harvest chain can vary by crop (see Trevor Suslow UC Davis resource material referenced below).

Suslow, Trevor. 1997. Posthavest Chlorination – basic properties and key points for effective disinfection. Publication 8003, University of California, Division of Agriculture and Natural Resources (http://anrcatalog.ucdavis.edu/pdf/8003.pdf).



PPT 6-64: Monitor Process Water

Two of the most important places from which to select water samples:



PPT 6-65: Monitor Process Water (cont'd)

Hydrocoolers are another place to sample for water quality determinations.

Monitor Process Water (cont'd)

- Top ice and liquid-ice injection
  - Ice makers

Photos: William C. Hurst, University of Georgia

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PPT 6-66: Monitor Process Water (cont'd)

Quality of water when making ice should meet the potable water standards.

Maintain Records

Packing Line: Tomato grading line
Specific Location: Water in dump tank
Control Limits: Available Chlorine = 100-150 ppm/ pH = 6.5-7.5

Date	Free Chlorine				pH		Operator Initials
	Time	Time	Time	Time	Time	Time	

Verified by: ____________________
Tomato Line Supervisor

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PPT 6-67: Maintain Records

As with all GAPs-related implementation, it is essential to document the measures you take to ensure food safety. In this example, available (free) chlorine and pH are to be monitored multiple times per day as a way of testing the disinfection level in water used in post-harvest processes. This is a form of quality assurance that will not only confirm proper disinfection levels but also alert you when remedial measures need to be taken.

Monitoring Options

- Test Strips
  - Make sure available or "free" chlorine measured.
- Colorimetric kits
  - If sample dilution is required, dilute with distilled water.
- Electronic Sensors
  - (Oxidation Reduction Potential, ORP, pH)

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PPT 6-68: Monitoring Options

Available chlorine is the equivalent of free chlorine. Free chlorine is the same as available chlorine. Test strips are cheapest. Colorimetric kits will have consumable material that will need to be replaced. Electronic sensors will need periodic calibration.

Resources

- Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. October 16, 2007. http://www.wga.com/LinkClick.aspx?link=DocumentLibrary%2f10+16+07+Leafy+Greens+Guidance+Clean.pdf&tabid=250&mid=1576

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PPT 6-69: Resources

This is the "leafy greens" document.

Resources

- Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables. February, 2008. http://www.cfsan.fda.gov/~dms/prodgui3.html

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PPT 6-70: Resources (cont'd)

No notes.

Resources

- National GAPs Program, Cornell University: "Food Safety Begins on the Farm: A Grower's Self-Assessment of Food Safety Risks" http://www.gaps.cornell.edu/FSBFEng.html

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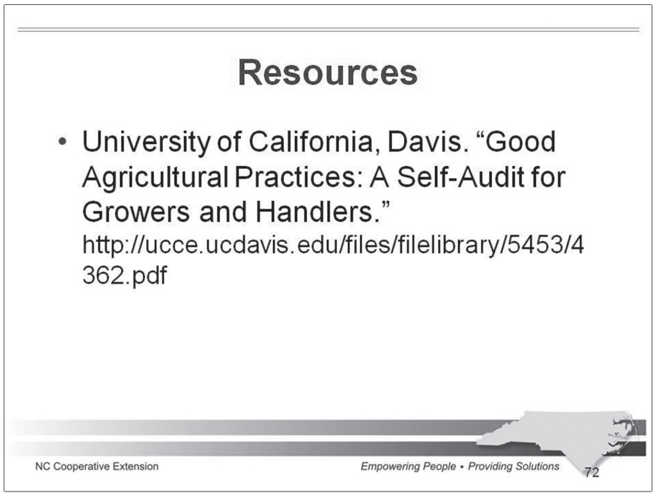
PPT 6-71: Resources (cont'd)

No notes.



PPT 6-72: Resources (cont'd)

No notes.

PPT 6-73: Resources

No notes.

Module 6: Water Quality

Pre-Test/Post-Test

ID Number/Name: ____ Date: ______________

1. Water is not considered a source of or vehicle for microbial pathogens. .... True or False

2. The most common source of water contamination is human or animal feces. .... True or False

3. It is important to use potable water to mix pesticides so that crops don't become contaminated with pathogens. .... True or False

4. Excluding animals from irrigation ponds and other surface waters used to irrigate crops is considered a good practice. .... True or False

5. Irrigating crops with surface water provides the lowest risk for produce contamination. .... True or False

6. The three common indicator organisms used to test for water safety are total coliform, fecal coliform and generic *E. coli.* .... True or False

7. A quantitative total coliform water test is the best microbial test available indicating the safety of water for production or post-harvest handling practices for produce. .... True or False

8. One way water samples are quantified is by MPN/100 ml. MPN means:
- ❑ Multi-probable nodules
- ❑ Most probable number
- ❑ Method plating number

9. FDA considers any crop that has come in contact with flood waters to be "adulterated" and cannot be sold for human consumption. .... True or False

10. Water utilized in postharvest handling operation should be up to EPA Recreational Water Standards. .... True or False

Module 6: Water Quality

Pre-Test/Post-Test Answers

1. Water is not considered a source of or vehicle for microbial pathogens. .... True or **False**

2. The most common source of water contamination is human or animal feces. .... **True** or False

3. It is important to use potable water to mix pesticides so that crops don't become contaminated with pathogens. .... **True** or False

4. Excluding animals from irrigation ponds and other surface waters used to irrigate crops is considered a good practice. .... **True** or False

5. Irrigating crops with surface water provides the lowest risk for produce contamination. .... True or **False**

6. The three common indicator organisms used to test for water safety are total coliform, fecal coliform and generic *E. coli*. .... **True** or False

7. A quantitative total coliform water test is the best microbial test available indicating the safety of water for production or post-harvest handling practices for produce. .... True or **False**

8. One way water samples are quantified is by MPN/100 ml. MPN means:
    - ❑ Multi-probable nodules
    - ✓ **Most probable number**
    - ❑ Method plating number

9. FDA considers any crop that has come in contact with flood waters to be "adulterated" and cannot be sold for human consumption. .... **True** or False

10. Water utilized in postharvest handling operation should be up to EPA Recreational Water Standards. .... True or **False**