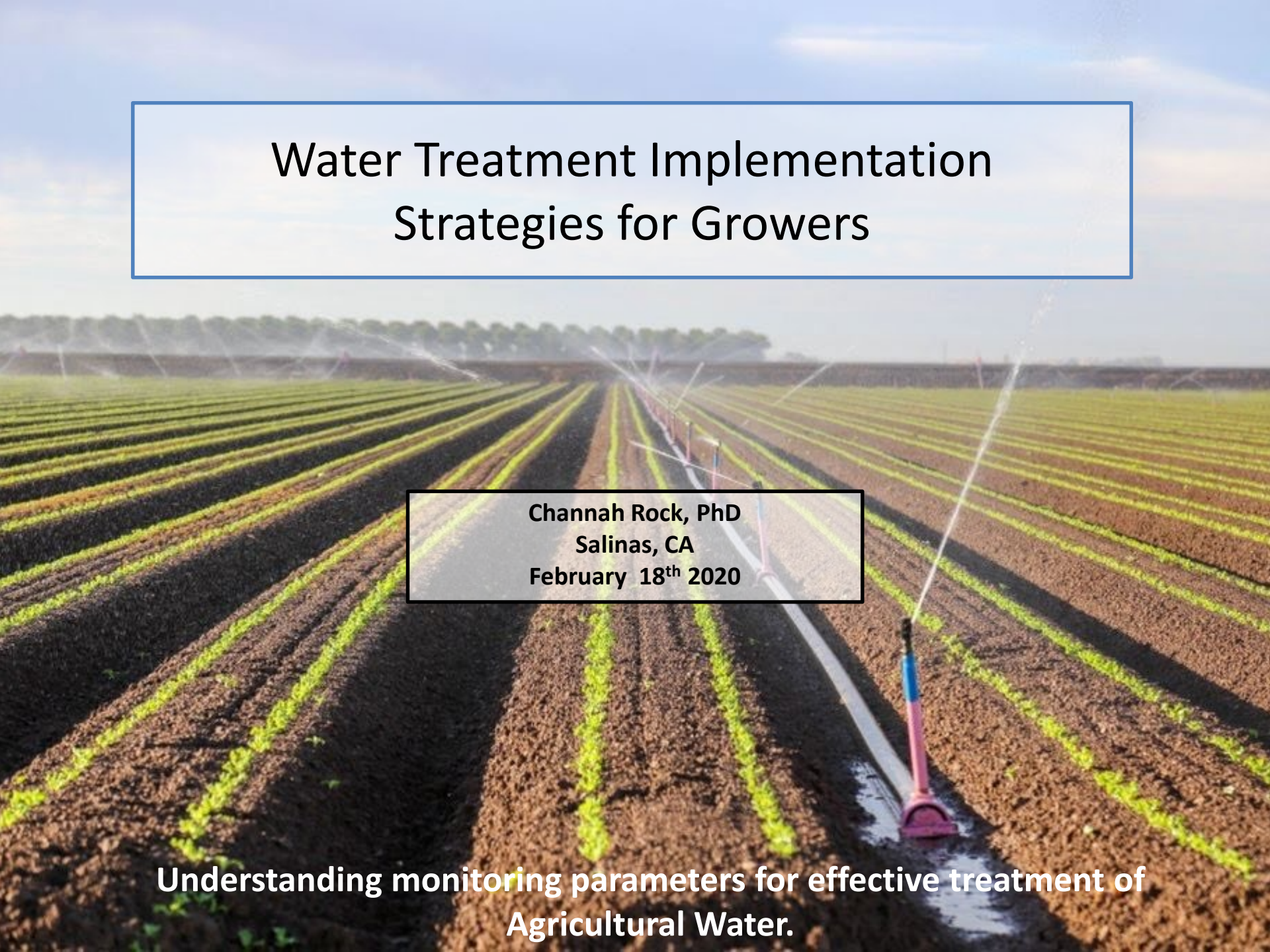
Water Treatment Implementation Strategies for Growers



Channah Rock, PhD
Salinas, CA
February 18th 2020

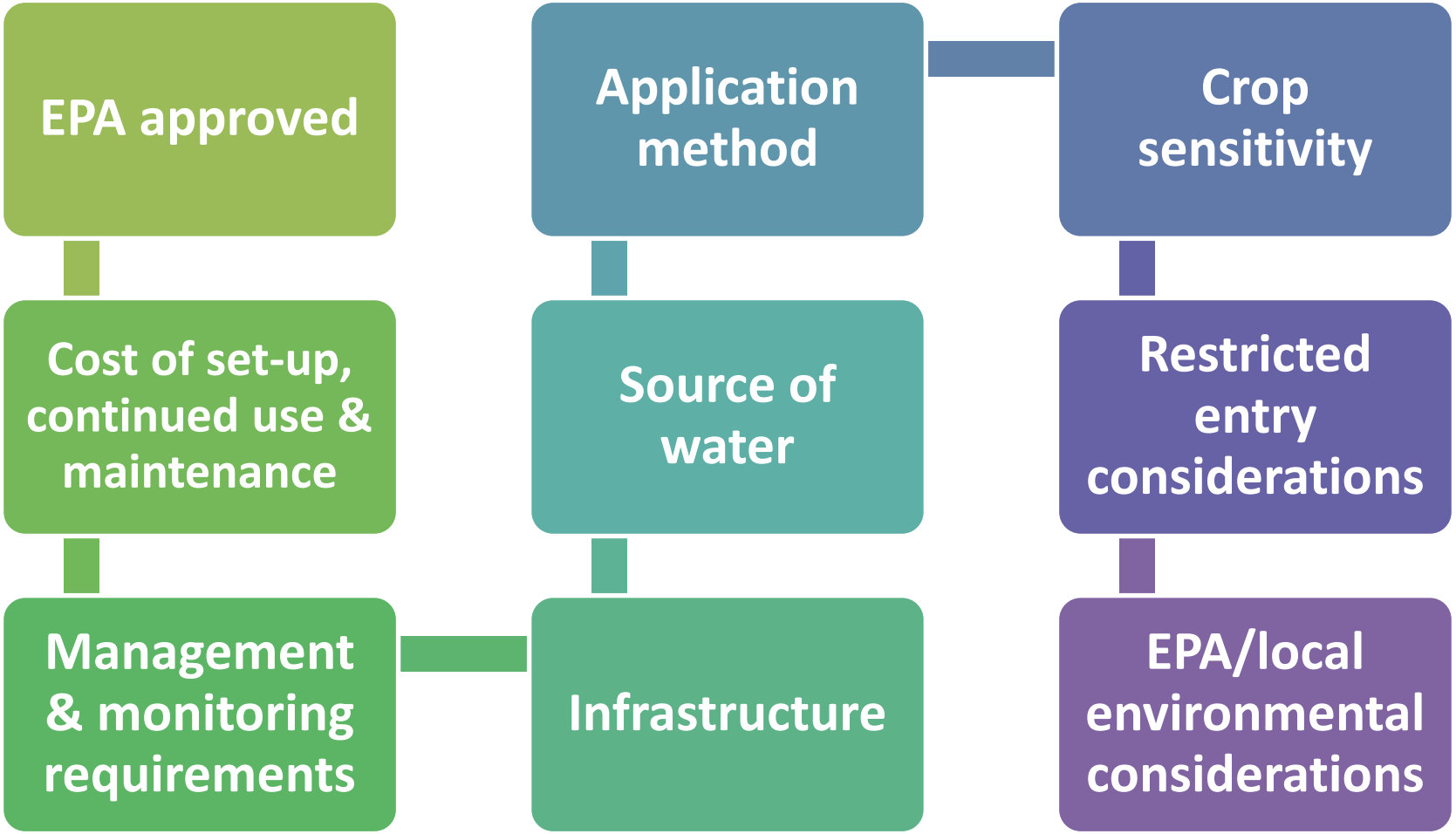
Understanding monitoring parameters for effective treatment of Agricultural Water.

New LGMA Water Metrics

- Approved April 18th, 2019
- **Type A** (groundwater, municipal) or **Type B** (surface)
- < 21 days to harvest & overhead irrigation
- **Non-detect generic *E. coli*** with a SSM of 10 CFU or MPN in any one sample

- Water should be treated with **EPA approved sanitizers** in accordance with label specifications, guidelines for use and consideration of environmental impacts.

How to choose a water treatment method?



Commonly Used Water Treatment Chemicals or Devices

- **Physical (Pesticide device)**
  - Heat Sterilization
  - Ultra Violet Light (UV)
  - Filtration (Membrane, or other media)
  - Ozone generator
- **Chemical**
  - Peroxyacetic Acid (PAA)
  - Sodium Hypochlorite / Chlorine Dioxide / Chlorine Gas
  - Sodium or Calcium Hypochlorite
  - Copper / Silver Ionization
  - Bromine

Produce Safety ALLIANCE

The Water Analysis Method Requirement in the FSMA Produce Safety Rule

Don Stoeckel, Connie Fisk, Donna Pahl, Gretchen Wall, Kristin Woods, and Elizabeth A. Bihn

Updated January 2018

The topic of water testing, including the sampling schedule and method used to enumerate *E. coli*, comes up at nearly every Produce Safety Alliance (PSA) Grower Training Course and Train-the-Trainer Course. The Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR) requires some produ... the quality of their agricu... of generic *E. coli* using EP... another "scientifically val...

- **Compliance Dates for Monitoring Under the FSMA Produce Safety Rule**: When it comes to water sampling compliance dates, the published Rule says that no farm is required to begin its agricultural water testing using

Last revised: 1/6/2017

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LABEL INFORMATION

Produce Safety ALLIANCE

	Approvals and Registrations		EPA Label						
Trade Name	EPA Reg. No.	Organic Materials Review Institute (OMRI) Listing	Link to EPA Label	Instructions For Use on Non-Porous Food-Contact Surfac	Instructions For Use Washing Fruits and Vegetables	Instructions For Use in Irrigation Water	Labeled For Use to Control Public Health Organisr	EPA Accepted Date	
Accutab	748-295	Allowed with restrictions	Label PDF	Yes See Page 14	Yes See Page 22	Yes See Page 27	No	1/13/14	
Adox 750	9150-8	Not listed	Label PDF	Yes See Page 9	Yes See Page 10	Yes See Page 9	No	4/14/15	
Adox 3125	9150-7	Not listed	Label PDF	Yes See Page 9	Yes See Page 10	Yes See Page 9	No	9/7/16	
Agchlor 310	2792-62	Not listed	Label PDF	Yes See Page 7	Yes See Page 7	No	No	5/23/12	
Anthium Dioxcide	9150-2	Not listed	Label PDF	Yes See Page 7	No	No	No	9/6/16	
Antimicrobial Fruit and Vegetable Treatment	1677-234	Not listed	Label PDF	No	Yes See Page 3	No	For Washing Fruits and Vegetables	11/30/16	
Bacticide	72315-6	Not listed	Label PDF	Yes See Page 6	Yes See Page 12	Yes See Page 4	No	7/9/15	
BioSide HS 15%	63838-2	See Notes for restrictions	Label PDF	Yes See Page 4	Yes See Page 6	Yes See Page 7	For Food Contact Surfaces	3/7/16	
Bromicide 4000	83451-17	Not listed	Label PDF	No	Yes See Page 4	No	No	12/31/15	
Bromide Plus	8622-49	Not listed	Label PDF	No	Yes See	No	No	8/7/13	

https://producesafetyalliance.cornell.edu/resources/general-resource-listing

Chemical vs. Device

- Chemicals (antimicrobial pesticides) must be EPA registered for their use and be targeted under the **Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)** before they can be lawfully used- "labeled for intended use"
  - Chemicals may have supplemental information based on scientific studies within labeled uses that set limits for control of foodborne pathogens

- Pesticide devices are physical treatments (non-chemical)
- Pesticide devices are regulated by EPA but do not require EPA registration
- Some states may require registration of pesticide devices

EPA Regulation of Chemicals

- Required for chemicals (antimicrobial pesticide products)
  - Label should include EPA *registration* number and instructions for treating irrigation water
  - Some states may also have registration and environmental requirements

- There is no EPA-approved chemical treatment of production agricultural water for reducing microbiological indicators (like *E. coli*) or enteric pathogens; **however, scientific studies may exist that set limits for control of foodborne pathogens or indicators**
  - Chemicals should not exceed limits set for uses on the label (e.g., concentration, contact time, etc.)

Example: Chemical Disinfection

- Disinfectants/Sanitizers do not kill instantaneously on contact. The rate of inactivation depends on 5 factors:

1. The Pathogens/Indicators
2. Chemical Concentration, C (mg/l)
3. Contact Time, T (minutes)
4. Temperature of water
5. pH of water

Disinfectant Effectiveness

Characteristics of five most common disinfectants

Issue	Disinfectant				
	Free chlorine	Combined chlorine	Chlorine dioxide	Ozone	Ultraviolet light
Effectiveness in disinfection					
Bacteria	Excellent	Good	Excellent	Excellent	Good
Viruses	Excellent	Fair	Excellent	Excellent	Fair
Protozoa	Fair to poor	Poor	Good	Good	Excellent
Endospores	Good to poor	Poor	Fair	Excellent	Fair
Frequency of use as primary disinfectant	Most common	Common	Occasional	Common	Emerging use
Regulatory limit on residuals	4 mg/L	4 mg/L	0.8 mg/L	~~NO~~ RESIDUAL	~~NO~~ RESIDUAL
Formation of chemical byproducts					
Regulated byproducts	Forms 4 THMs[a] and 5 HAAs[b]	Traces of THMs and HAAs	Chlorite	Bromate	None
Byproducts that may be regulated in future	Several	Cyanogen halides, NDMA	Chlorate	Biodegradable organic carbon NDMA	None known
Typical application					
Dose, mg/L (kg/ML)	1–6	2–6	0.2–1.5	1–5	20–100 mJ/cm^2
Dose, lb/MG	8–50	17–50	2–13	8–42	—

Factor	Issue/Problem	Solution
Organic Matter	Organic matter load in the water can affect disinfection efficiency. Higher **organic matter levels consume more disinfectant** and therefore, in order to reach a particular concentration, addition of more disinfectant is needed.	Preliminary water **filtration** may substantially decrease organic matter load, thus reducing the amount of chlorine/PAA needed for effective disinfection.
Contact Time	The duration of time allowed for **contact and reaction between the disinfectant and the microorganisms** is extremely important.	At **longer contact times lower concentrations** of disinfectant can be used and vice versa.
Water pH	**Free chlorine in water exists in 3 forms**: Cl2 (dissolved gas), HOCl (Hypochlorous acid), OCl- (hypochlorite).	The relative proportions of these three forms are determined by the water pH. HOCl is 100 times more effective than OCl- therefore water **pH should be monitored**.
Temperature	**Disinfection can be more effective in higher temperature**, although too high temperature can also reduce the efficiency of disinfection.	**Temperatures should be monitored** so adequate disinfectant dosing can be conducted. A decrease of 10 degrees Celsius can reduce efficiency of disinfection by up to 50-60%.
Turbidity	Turbid water that contains suspended particles allows **bacteria to "hide" in between the particles**, thus “evading” contact with the disinfectant.	**Filtering** the water prior to disinfection can increase the ability to adequately treat the water with the disinfectant.

Validation vs. Verification

- **Validation:** The goal of conducting **validation** is to demonstrate that a process, when operated within established limits, produces a product of consistent and specified quality with a high degree of assurance. **Validation of water treatment** systems is necessary to obtain **water** with all desired quality attributes.

- **Verification:** The process of confirming the truth, accuracy, or validity of something.

Validation of Microbial Reduction

Only take micro test AFTER verification of ppm!!!

Non-detect generic

≤ 10 MPN generic *E.coli*/100mL (SSM)

≤ 99 MPN Total Coliform/100mL

Monitoring

- Conducting a planned sequence of observations or measurements to assess whether a process, point or procedure is under control and to produce an accurate record for future use in verification

- Without adequate monitoring, there is no way to know (or prove) if critical limits are being met

- The purpose of monitoring is to:
  - Track the operation of the process
  - Identify trends
  - Identify when there is a loss of control
  - Provide written documentation that the process is in control
  - **What? How? Frequency? Who?**

Monitoring – What?

- A measurement or observation
  - Determines if operating within limits established in your SOP

- Examples:
  - Time
  - Antimicrobial pesticide product residual (ppm or mg/L)
    - Free chlorine, chlorine dioxide, peroxyacetic acid
  - Temperature
  - pH
  - % UV intensity

Examples of How to Monitor

- Timer
- Thermometer
- pH meter
- Scales
- Test strips
- Titration
- Analytical equipment
- Gas analyzer

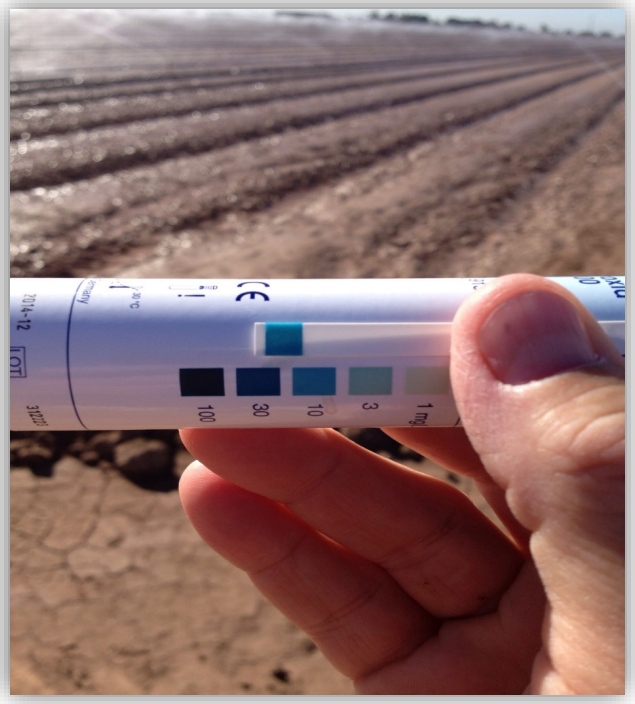
Monitoring Disinfectants

- pH and ion specific test strips
  - Least expensive, least accurate, very easy to use

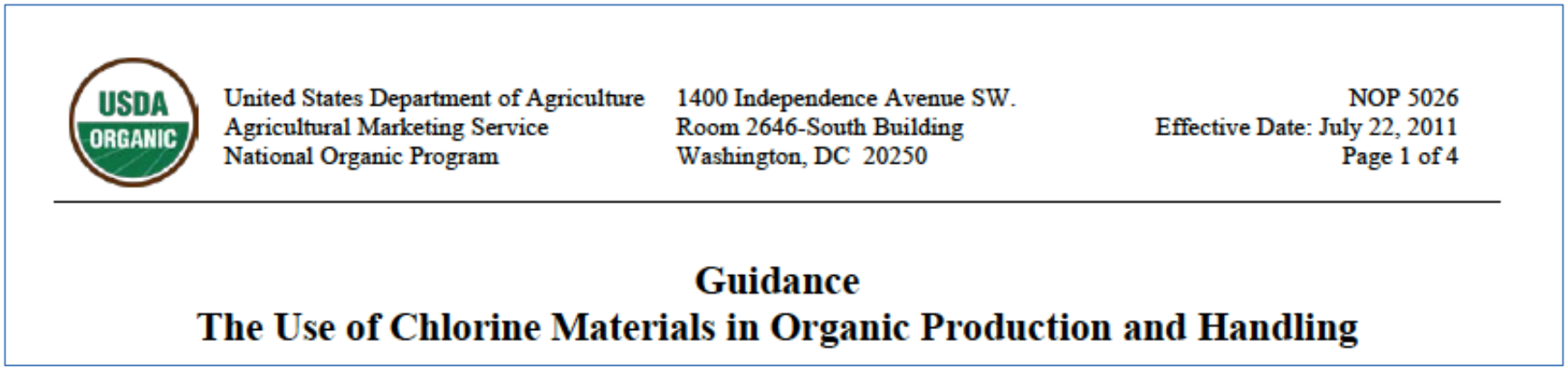
- Colorimeters (titration, spectrophotometric, direct read)
  - Water changes color in response to chlorine concentration
  - Medium cost, may be the most accurate, more difficult to use

- Electrodes (ion specific)
  - More expensive, very easy to use

Verification of Proper Concentration (PPM)



National Organic Standards Board



United States Department of Agriculture
Agricultural Marketing Service
National Organic Program

1400 Independence Avenue SW.
Room 2646-South Building
Washington, DC 20250

NOP 5026
Effective Date: July 22, 2011
Page 1 of 4

Guidance
The Use of Chlorine Materials in Organic Production and Handling

"**Maximum residual disinfectant level**" is a term defined by the Environmental Protection Agency (EPA) at 40 CFR §§ 141.2, 141.65 as the highest level of a disinfectant allowed in drinking water.

This level is currently established by EPA at **4 mg/L for chlorine** (as Cl2) and **0.8 mg/L for chlorine dioxide**."

Critical Limits

- A maximum and/or minimum value to which a parameter must be controlled to prevent, eliminate, or reduce to an acceptable level the occurrence of the identified hazard
  - Human pathogen
  - Microbial indicator

- Critical limits should relate to a process that can be easily measured

Critical Limits – There May Be More Than One!

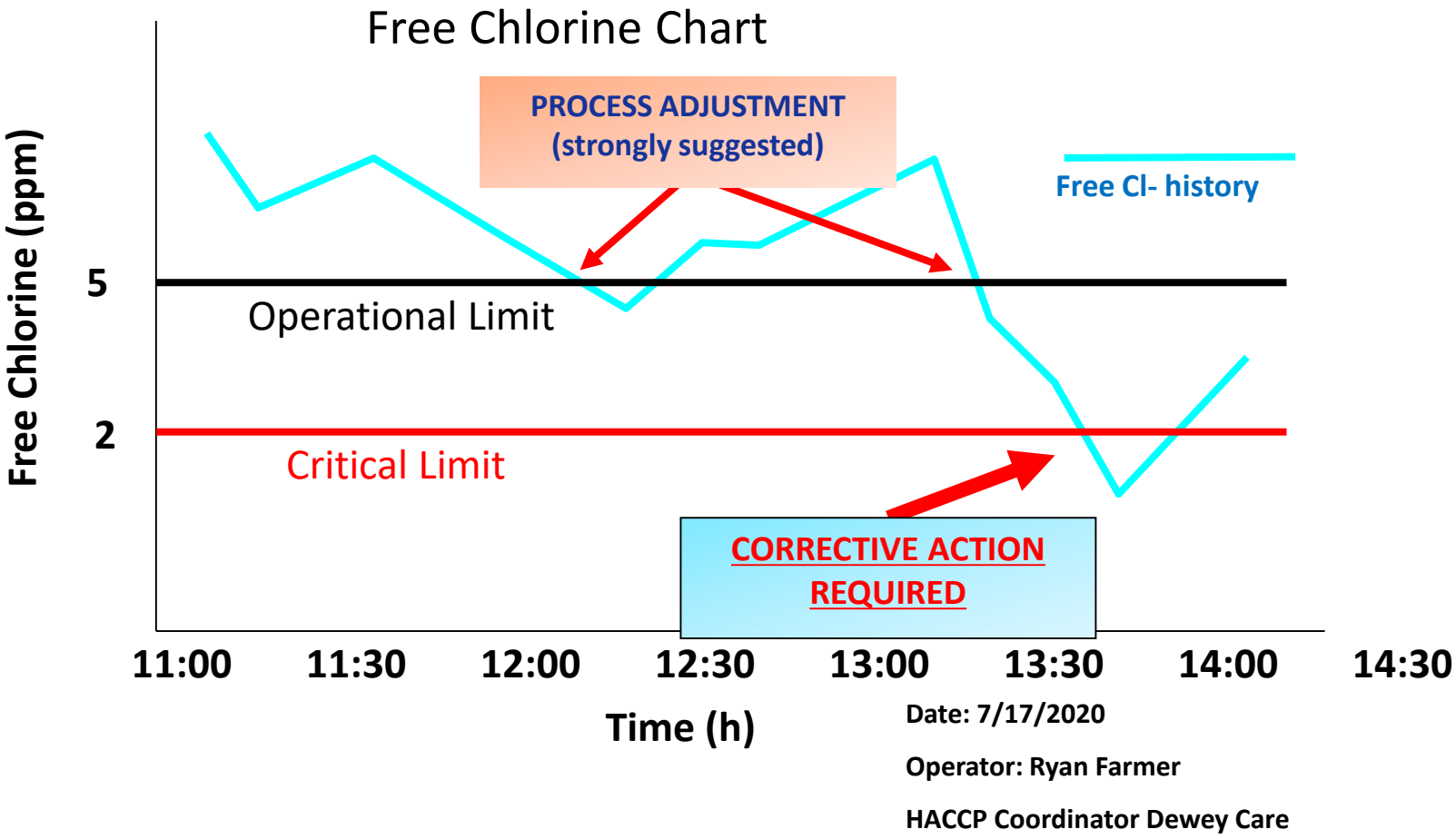
Antimicrobial pesticide products	Antimicrobial devices
• Chemical concentrations • Contact times • pH • Turbidity	• Temperatures • Membrane pore size • UV dose • Contact times • Turbidity

Critical vs. Operating Limits

- **Operating limit**: a criterion that is more stringent than a critical limit and that is used by an operator (irrigator) to reduce the risk of non-compliance

- **Process adjustment**: an action taken by an operator to bring the process back within operating limits

Example of Operating and Critical Limits, and Corrective Action- Example Only!



What needs to be in a water treatment SOP?

- A water treatment SOP may include:

1. Step-by-step instructions to ensure the water treatment is correctly implemented by following the SOP
2. Location and name of any supplies needed
3. When and how often practices should be completed
4. What records are needed/necessary
5. What critical limits need to be met
6. What is being monitored
7. What corrective actions to do if critical limits are not met

Important Considerations for Successful Implementation

- Will it work?
  - Pathogen loading
  - Contact time
  - Dosing requirement

- Capital Equipment Cost
- O&M Costs
- Worker Safety
- Ease of Use/Testing

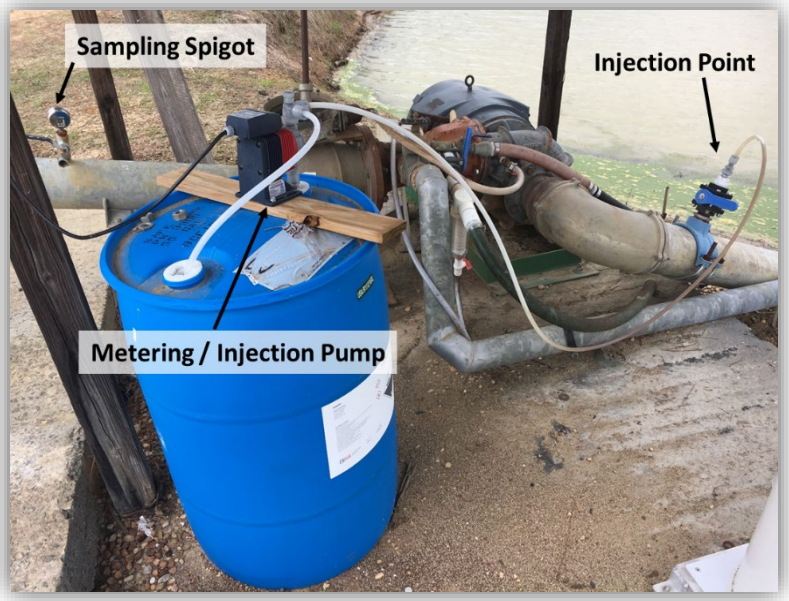


Figure 1. Pump station showing the metering / injection pump and injection port used to add Safe Zone PW3300 to the supply line of a center pivot irrigation system during a 2016 pilot study.

Ozone - eWater - Chlorine Dioxide - PAA - Sodium Hypochlorite

Start-up and Commissioning (>21 days) "INITIAL MICROBIAL WATER TREATMENT ASSESSMENT"

- Work should include system set-up, tuning and recording of system performance parameters, and perhaps validation.
  - Pump
  - Flow rate
  - Valve position
  - Chemical dose/use/tote lot #
  - Technician in charge (who?)
  - Chemical residual (ppm) @ **first or last** sprinkler head
  - **3 Micro tests at the last sprinkler head 20 mins apart**

"ROUTINE VERIFICATION OF MICROBIAL WATER QUALITY"

- Complete routine verification at some point after completing the Initial Microbial Water Treatment Assessment. This can be within the 21-days-to-scheduled-harvest window.

- **FREQUENCY:** once per unique system per season

- **CRITERIA:** There must be no detectable Generic *E. coli* in at least 2 of 3 samples. One sample can have up to 10 MPN of Generic *E. coli*

"LEVEL 1 ASSESSMENT"

- What if I performed my routine verification testing during the 21-day-to-scheduled-harvest window, but the water did not meet Type A criteria?

- **FREQUENCY:** During the next irrigation event, take five 100 milliliter samples from any point in the delivery system. One of the samples must be from the furthest point of the delivery system (i.e.: last sprinkler head).

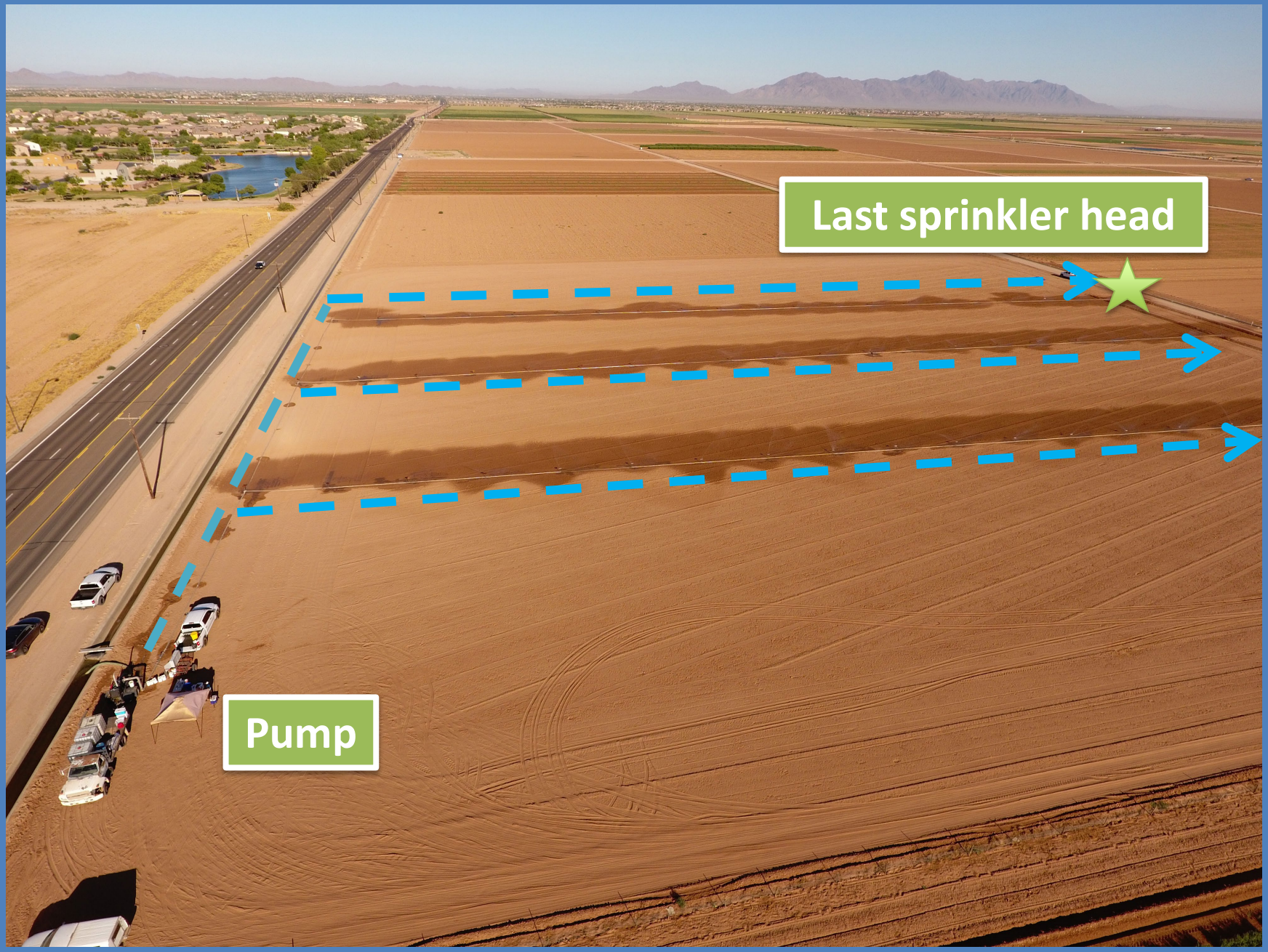
- **CRITERIA:** At least 4 of 5 tests must have no detectable generic *E. coli*. One test can have a maximum of 10 MPN of Generic *E. coli*.

Operational Considerations

1. Start-up and “commissioning” of water treatment systems
2. Qualifications
3. System monitoring
4. Maintenance of water systems
5. Treatment system review

Additional Considerations

- When to troubleshoot and re-verify?
- How long to wait after modification?
  - Purge
  - Re-stabilization
  - Re-verify at the first/last sprinkler head
- 5 acre plot, 1.5 gpm birds, 1000 gpm, 70 psi = ~35 to 45 minutes
- When to document?


Last sprinkler head
Pump

Challenges with treating reservoirs

- Algae
- Pre-treatment
- Sand filters – do you treat before or after?
- Maintaining residual

Questions?

Content adapted from: *Buchanan, J.R., , T.K. Chapin, , M.D. Danyluk, C.C. Gunter, L.K. Strawn, A.L. Wszelaki, F.J. Critzer. 2019. Bridging the GAPs: Approaches for Treating Water On-Farm. Curriculum V1.0.*

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Thank you!

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