

WATER QUALITY STANDARDS: HOW WE GOT HERE AND WHERE WE ARE

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IEH: NORTH AMERICAN LOCATIONS

- ▶ Environmental Engineer VI in Watershed Assessment Section at Delaware Department of Natural Resources & Environmental Control (2001- 2007)
- ▶ EVP (2007-present) at IEH

18 YEARS OF WATER QUALITY
EXPERIENCE

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	N	Salmonella	% Positive
Pistachios (kernels)	3,891	82	2.1%
Macadamia (raw)	197	3	1.5%
Walnuts (raw)	599	5	0.8%
Peanuts (raw)	10,163	68	0.7%
Hazelnuts (shelled)	303	2	0.7%
Pistachio (in-shell)	32,494	133	0.4%
Cashews (raw)	513	2	0.4%
Hazelnuts (in-shell)	70	0	0.0%
Pecans (raw)	573	0	0.0%
Pine Nuts (raw)	398	0	0.0%
TOTAL	49,201	295	0.6%

NUTS (FDA & IEH)

	N	# Positive	% Positive
<i>Salmonella</i>	3,891	48	1.23%
EHEC	3,891	11	0.28%
<i>Listeria spp</i>	1,285	1	0.08%
<i>Listeria mono</i>	1,285	0	0
<i>E. coli</i> O157	3,891	0	0

WHEAT (IEH)

	N	Salmonella	% Positive
Red Pepper	639	4	0.6%
Black Pepper	1,273	4	0.3%
Paprika	823	2	0.2%
Basil	534	1	0.2%
Oregano	675	1	0.1%
TOTAL	3,944	12	0.3%

SPICES (FDA BASELINE, N1 SAMPLING)

Type	N	# Positive	% Positive
Onion	150	2	1.33%
Cilantro	2,494	19	0.76%
Spinach	4,406	31	0.70%
Parsley	1,706	10	0.59%
Hot Peppers	1,970	6	0.30%
Sprouts (Alfalfa)	6,947	20	0.29%
Lettuce	12,621	16	0.13%
Green Onions	7,332	9	0.12%
Cantaloupe	9,985	11	0.11%
Tomatoes	13,947	2	0.01%
TOTAL	61,558	126	0.20%

USDA MDP 2004-09 (SALMONELLA & STEC)

Type	N	<i>Salmonella</i>	<i>L. mono</i>	% Positive
Cantaloupe	1,075	2	0	0.19%
Mango	1,176	2	3	0.43%
Cucumber	1,160	0	5	0.43%
TOTAL	3,411	4	8	0.35%

FRUIT (FDA BASELINE, N1 SAMPLING)

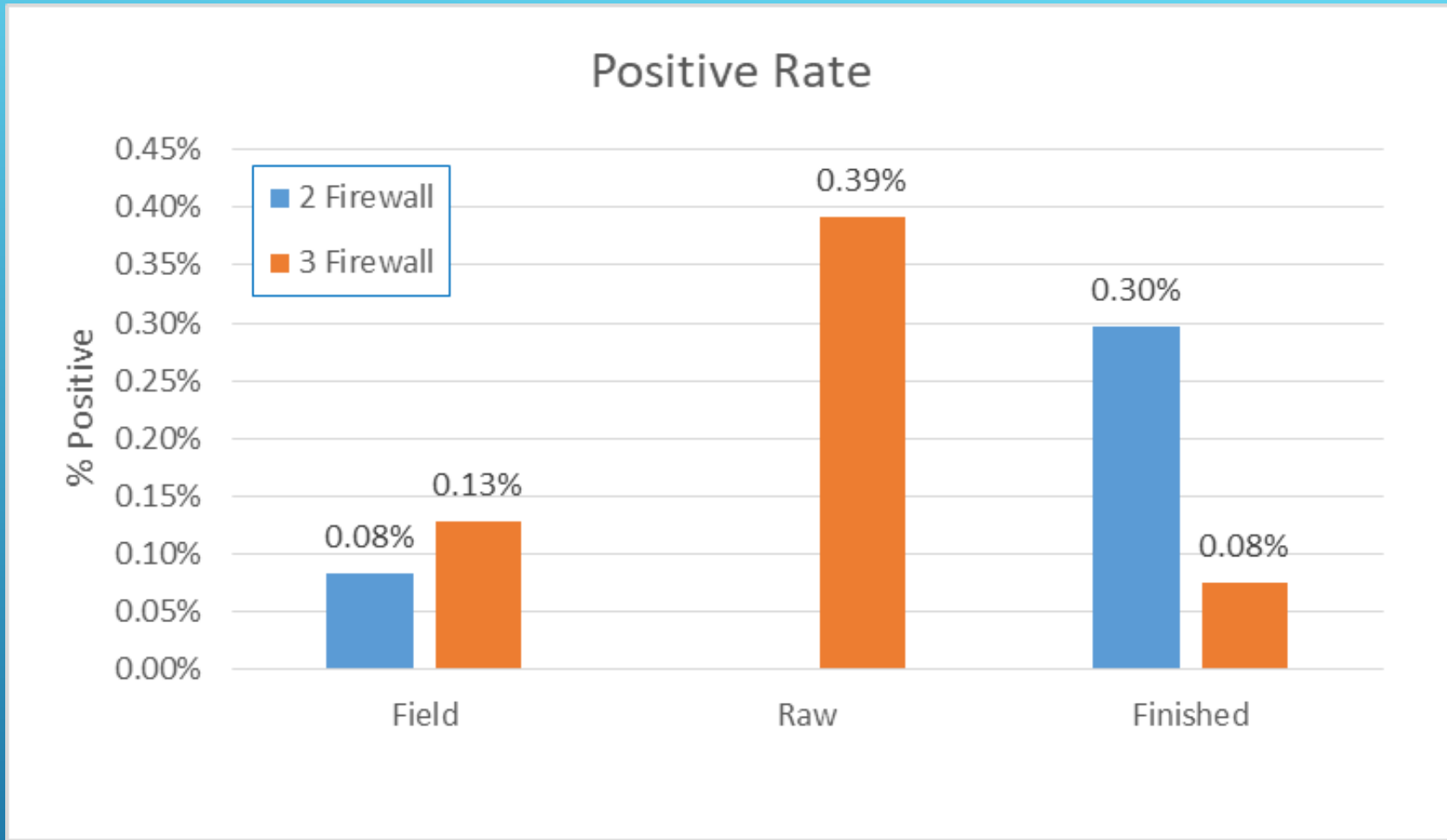
	N	Salmonella	STEC	% Salmonella or STEC Positive		L. mono	% L. mono Positive
Cantaloupe	1,075	2	NA	0.2%		0	0.0%
Mango	1,176	2	NA	0.2%		3	0.3%
Cucumber	1,160	0	NA	0.0%		5	0.4%
TOTAL	3,411	4	NA	0.1%		8	0.2%
Iceberg	3,682	1	0	0.03%		NA	NA
Romaine	5,971	3	5	0.1%		NA	NA
Spinach	6,080	4	12	0.3%		NA	NA
Iceberg	1,526	NA	NA	NA		2	0.1%
Romaine	2,418	NA	NA	NA		7	0.3%
Spinach	3,780	NA	NA	NA		6	0.2%
TOTAL		16	17	0.2%		31	0.2%

PRODUCE (FDA BASELINE, N1 SAMPLING)

- ▶ N = 662,395
- ▶ Tested for *Salmonella*, EHEC and O157

	2 Firewall	3 Firewall	Total
Field	231,541	7,001	238,542
Finished	75,599	136,985	212,584
Raw	na	211,269	211,269

SALINAS AND YUMA, 2016 THROUGH 2018, LEAFY GREENS



PATHOGEN POSITIVE RATE

	<i>Salmonella & EHEC</i>			
	Negative	Positive	N	% Positive
Broccoli	876	10	886	1.14%
Cauliflower	408	3	411	0.74%
Snow/snap peas	1025	7	1032	0.68%
Spinach	30,079	205	30,284	0.68%
Veggie tray	2783	9	2792	0.32%
Celery	4995	8	5003	0.16%
Lettuce (other)	19,530	11	19,541	0.06%
Blend/Salad	32,282	13	32,295	0.04%
Kale	7,046	2	7,048	0.03%
Romaine	3,664	1	3,665	0.03%

2018 TO SEPT 2019 SALINAS & YUMA
 PROCESSED PRODUCT

- ▶ John Snow, 1854, London, consumption of water from a sewage-contaminated public well led to cholera
- ▶ Theodor Escherich, 1885, Germany, developed *E. coli* index to assess public health risk
- ▶ 1897, the American Public Health Association (APHA) adopted standard procedures to test for coliform
 - ▶ 1909 procedures published in Standard Methods for the Examination of Water and Wastewater
 - ▶ 1914, the U.S. Public Health Service (USPHS) set a no coliform drinking water standard

OVER A CENTURY AND A HALF OF THE
INDICATOR APPROACH

- ▶ The Federal Water Pollution Control Act of 1948 was the first major U.S. law to address water pollution.
- ▶ As amended in 1972, the law became commonly known as the Clean Water Act (CWA).
 - ▶ NPDES
 - ▶ Point & Non-point Sources
 - ▶ Pollution Control Strategies
 - ▶ Dredging Regulations
 - ▶ Wetlands Protection
 - ▶ Revisions in 1977, 1981, 1987, 1990, etc.

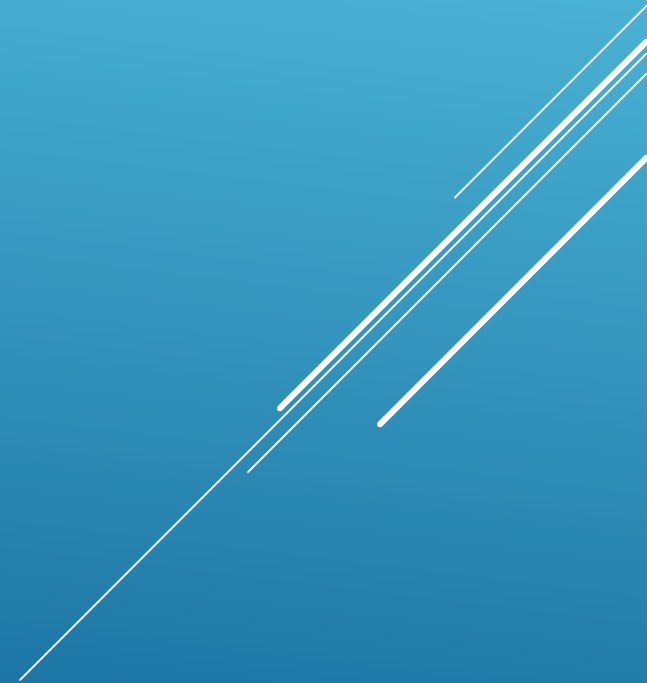
CLEAN WATER ACT 1972

- ▶ Regulates the nation's public drinking water supply
- ▶ Amended in 1986 and 1996
- ▶ Requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells

THE SAFE DRINKING WATER ACT (SDWA) 1974

- ▶ Microorganisms
- ▶ Disinfectants
- ▶ Disinfection Byproducts
- ▶ Inorganic Chemicals
- ▶ Organic Chemicals
- ▶ Radionuclides

NATIONAL PRIMARY DRINKING WATER REGULATIONS



Public water systems: ≥ 15 service connections or serve at least 25 people per day for 60 per year

- ▶ Drinking water standards apply to water systems differently based on their type and size:
- ▶ Community Water System
- ▶ Non-Community Water System
 - ▶ Non-Transient Non-Community Water System
 - ▶ Transient non-community water system

PUBLIC WATER SYSTEMS: ≥ 15 SERVICE CONNECTIONS OR SERVE AT LEAST 25 PEOPLE PER DAY FOR 60 PER YEAR

- ▶ Total Coliform Testing.
- ▶ Negative: Pass
- ▶ Positive: Test For *E. coli*, Retest Also Required (generally 3)
 - ▶ *E. coli* negative pass
 - ▶ *E. coli* positive fail

TOTAL COLIFORM RULE (REVISED 2013)

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- ▶ Irrigation Water vs. Drinking Water
- ▶ Irrigation Water vs. Recreational Water

APPLICABILITY TO IRRIGATION WATER
?

			Single Sample Max (cfu/100ml)			
	GI Illness per 1,000	Geomean* (cfu/100ml)	Designated Beach	Moderate Full Contact	Light Full Contact	Infrequent Full Contact
Freshwater: enterococci	8	33	61	78	107	151
Freshwater: <i>E. coli</i>	8	126	235	298	409	575
Marine Water: enterococci	19	35	104	158	276	501

* ≥ 5 samples in a 30 day period

AMBIENT WATER QUALITY CRITERIA FOR BACTERIA – 1986 (RECREATIONAL WATERS)

DELMARVA REPORTING
(302) 734-7647 or 368-0516

32

-Dufour - 2/23/90-

And I have to caution you, this was a small study. It was intended to be a preliminary study because we thought that the next year we would go on and do the definitive study. Unfortunately, that was a bad budget year. One of the first places they looked to to cut the budget was in the laboratories, and we were it.

DUFOUR TRANSCRIPT 1990

- ▶ August, 1996, James R. May, Esq., Director of the Environmental Law Clinic at Widener University School of Law, on behalf of the American Littoral Society (and its affiliate, Delaware River Keeper Network) and the Sierra Club. The Complaint asks the Court to order EPA to:
 - ▶ Comply with CWA requirements for TMDLs in Delaware on a short time line.
 - ▶ Commit to updating Delaware's Continuing Planning Process which serves as the overall framework for water resources management in the State. 1996
 - ▶ Not issue or approve any new or renewed National Pollutant Discharge Elimination System (NPDES) permits discharging into impaired waters for which TMDLs or TMDTLs (Total Maximum Daily Temperature Loads) have not been established.
 - ▶ Cease any additional grant funding to Delaware to administer the 303(d) program until the State's 303(d) list meets the requirements of the CWA.
 - ▶ Administer the NPDES program for Delaware until the State has an EPA approved CPP in place.

DELAWARE'S TMDL LAWSUIT 1996

- ▶ The Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000 requires each state and territory with coastal recreation waters to adopt into their water quality standards by April 10, 2004, bacteria criteria that are "as protective of human health as" our 1986 bacteria criteria.

THE BEACHES ENVIRONMENTAL
ASSESSMENT AND COASTAL HEALTH
(BEACH) ACT AMENDED THE CLEAN
WATER ACT IN 2000.



Microbial Source Tracking Guide Document



MICROBIAL SOURCE TRACKING (2005)

- ▶ EXPERTS SCIENTIFIC WORKSHOP ON CRITICAL RESEARCH NEEDS FOR THE DEVELOPMENT OF NEW OR REVISED RECREATIONAL WATER QUALITY CRITERIA

- ▶ Summary of Critical Path Research Areas Identified as High Priority
 - (1) human health impacts from different sources of fecal contamination;
 - (2) measurement issues: climatic, geographic, and temporal variability;
 - (3) determining risk level and subpopulations of concern; and
 - (4) indicators and methods for measuring fecal contamination.

AIRLIE CENTER
WARRENTON, VIRGINIA
MARCH 26-30, 2007

	36 Illness per 1,000 (cfu/100ml)		30 Illness per 1,000 (cfu/100ml)	
	Geomean	STV	Geomean	STV
Enterococci (Marine & Fresh)	35	130	30	110
<i>E. Coli</i> (Fresh)	126	410	100	320

statistical threshold value (STV) approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken.

2012 RWQ CRITERIA

- ▶ Need for a viral indicator; coliphage as a predictor of gastrointestinal illnesses;
- ▶ How coliphage may be useful as an indicator of wastewater treatment performance; male-specific vs somatic coliphage

2016 COLIPHAGE EXPERTS WORKSHOP



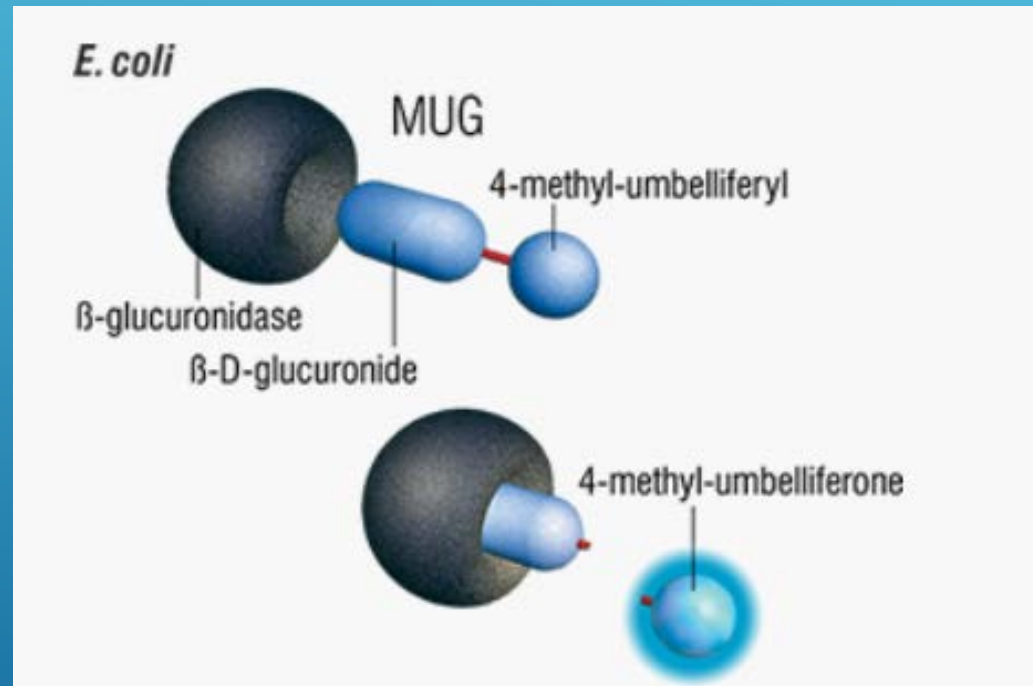
- ▶ Detailed assessment of the state of the science and advances made since 2010
- ▶ EPA has decided not to revise the 2012 Recreational Water Criteria
- ▶ The Agency believes further research and analysis as identified in the report will contribute to the EPA's future review of the 2012 RWQC.

FIVE-YEAR REVIEW OF THE 2012 RWQC

IRRIGATION WATER TESTING

- ▶ FSMA incorporated EPA Recreational Water Quality Standards
 - ▶ Recreational water standards for fresh water allow for 8 illnesses in 1000 swimmers
- ▶ Do we achieve our food safety objectives by using a standard that allows for 8 illnesses per 1,000 swimmers to be used for irrigation of minimally processed ready to eat products?
 - ▶ Most generic *E. coli* tests do not detect *E. coli* O157

E. COLI USE β -GLUCURONIDASE TO METABOLIZE MUG AND CREATE FLUORESCENCE



- ▶ *E. coli* O157, at +93, has a single nucleotide polymorphism (SNP) in the uidA gene that encodes for the β -D-glucuronidase (GUD) enzyme
- ▶ Genetic tests targeting the uidA gene will detect despite the SNP
- ▶ uidA gene is not considered a required marker for O157 by the USDA (rfb and eae only)
- ▶ +93 SNP differentiates O157 from other STEC (FDA-BAM)

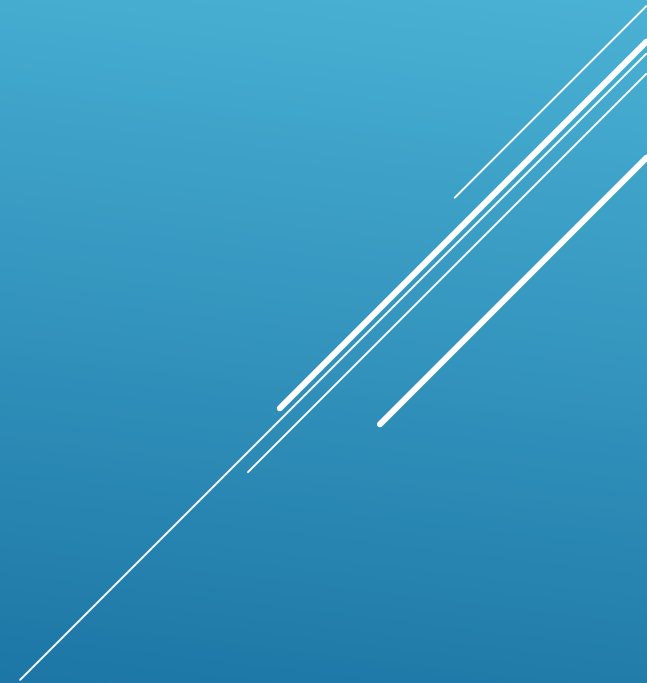
E. COLI HAVE THE UIDA GENE THAT PROVIDES THE MECHANISM FOR β -GLUCURONIDASE ACTIVITY

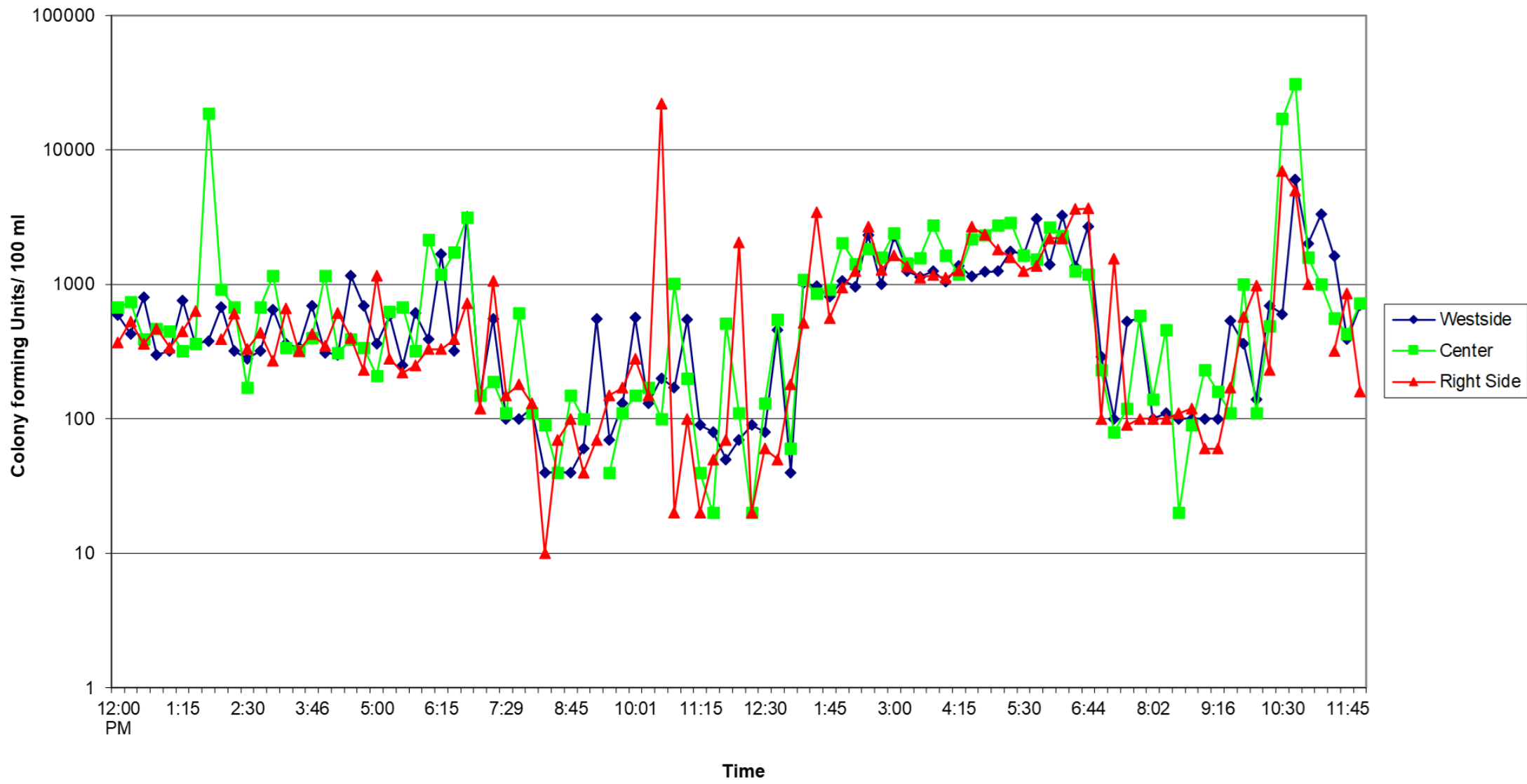
Detect O157	Target glucuronidase activity	Number	Type
no	yes	EPA 1603	Membrane Filtration
no	yes	EPA 1604	Membrane Filtration
no	yes	Idexx Colilert	MPN

IRRIGATION WATER TEST METHODS



THORNTON CREEK





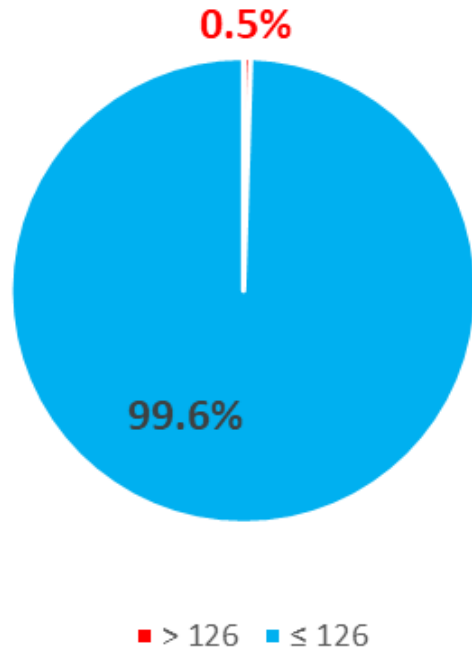
24 MONITORING (EVERY 15 MINUTES)

- ▶ N = 3,300
- ▶ Split samples (100 ml each)
 - ▶ *E. coli*: EPA 1604
 - ▶ *Salmonella*, EHEC and O157: AOAC 100701

~2011-2013 WATER STUDY (YUMA &
SALINAS, 2 PROCESSORS)



cfu generic *E. coli* per 100 mL



0.5%: 16
99.6%: 3,286

Negative	3,286	99.6%
Salmonella	4	0.1%
EHEC	12	0.4%
O157	0	0%
Overall	16	0.5%

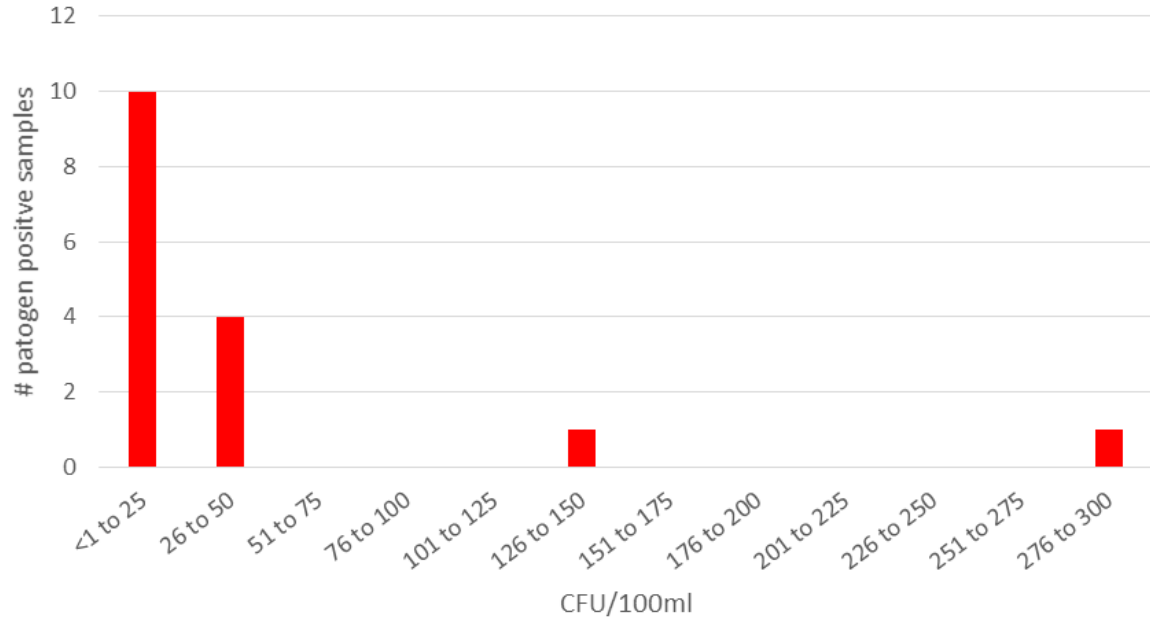
RESULTS

CFU/100 ml	Pathogen
140	Negative
148	EHEC
150	Negative
220	Negative
260	Negative
300	Negative
300	EHEC
310	Negative
330	Negative
>350	Negative
400	Negative
560	Negative
1,000	Negative
1,100	Negative
1,100	Negative
>1,100	Negative

- ▶ Of the 16 samples that exceeded the 126 cfu/100ml level, pathogens were only detected in 2 (both below STV)
- ▶ Water management decision based on STV of 410 cfu/100ml on 5 of 3,300 samples (0.2%)

E. COLI COUNT VS. PATHOGEN PRESENCE

Generic E. coli Count vs. Pathogen Postive

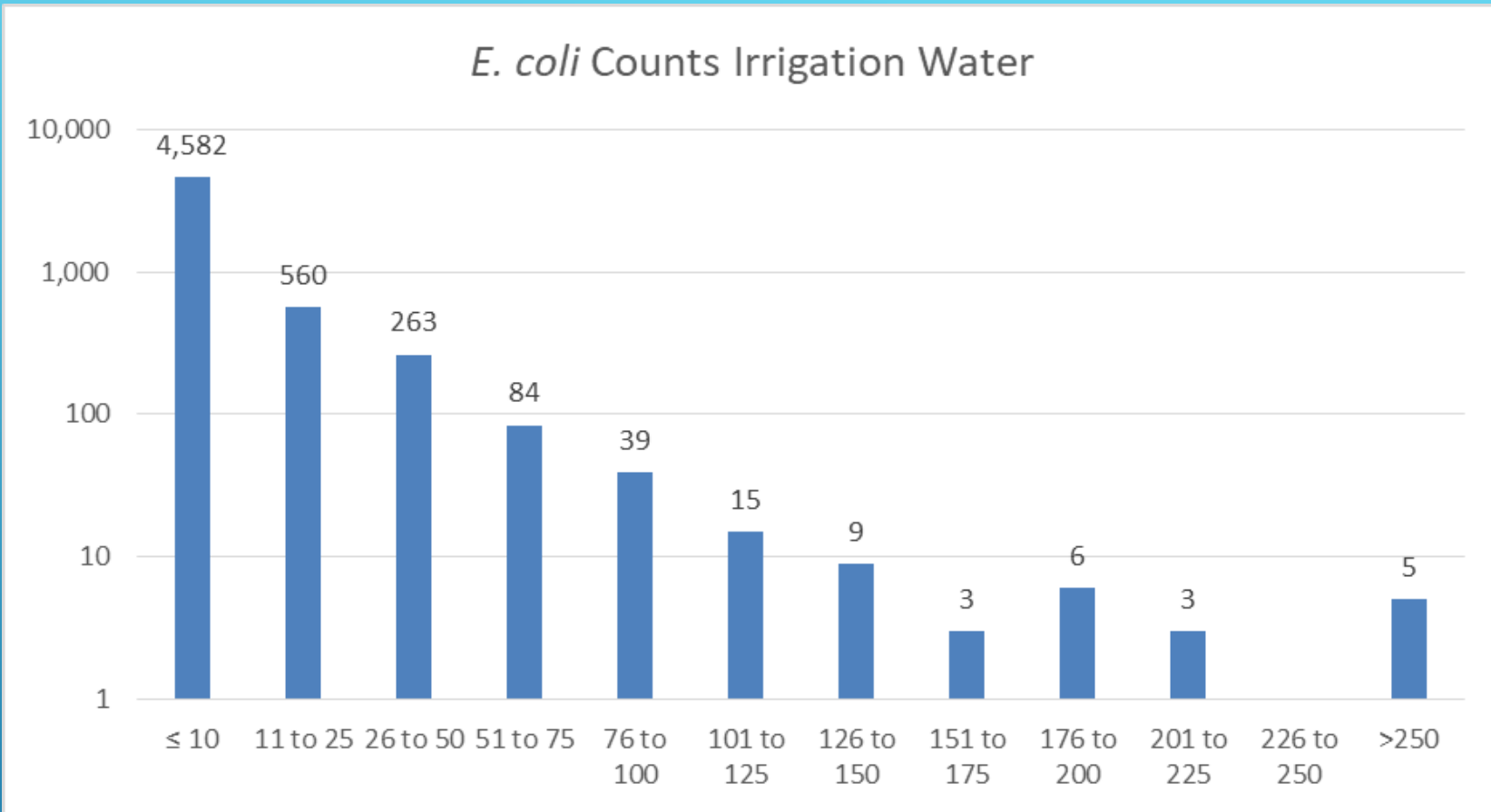


- ▶ Of the 16 samples that pathogen were detected, none warranted a water management decision based on the generic *E. coli* count
- ▶ Actual STV 410 cfu/100 ml:
- ▶ All water management decision based on the generic *E. Coli* count with respect to EHEC/O157/Sal were wrong (5 of 5)
- ▶ All samples that contained EHEC/O157/Sal were cleared based on the generic *E. Coli* count (16 of 16)

E. COLI COUNT VS. PATHOGEN PRESENCE

E. coli Counts Irrigation Water

Samples



cfu *E. coli*/100ml

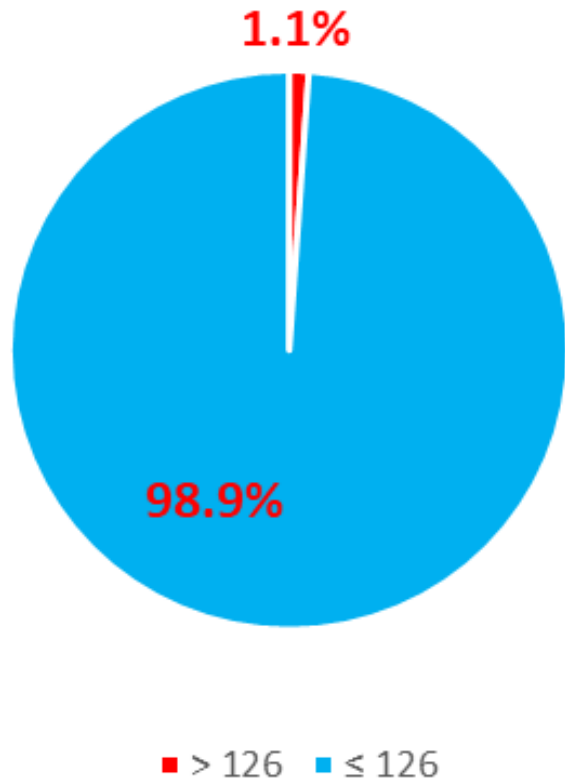
IRRIGATION TEST RESULTS, YUMA, 2018 THROUGH JAN 2019, N=5,569

(NOTE: THREE *E. COLI* O157 OUTBREAKS DURING THIS TIME PERIOD)

- ▶ N = 2,160
- ▶ Same sample
- ▶ Generic *E. coli*: EPA 1604
- ▶ *Salmonella*, EHEC, O157: AOAC 100701 on membrane filter from EPA 1604 test

AUGUST 2018 TO JAN 2019 YUMA WATER STUDY (ALL GROWERS)

cfu generic *E. coli* per 100 mL



1.1%: 24
98.9%: 2,136

Negative	2136	98.9%
Salmonella	28	1.3%
Sal & EHEC	1	0.05%
EHEC	40	1.9%
O157	0	0%
Overall	69	3.2%

RESULTS

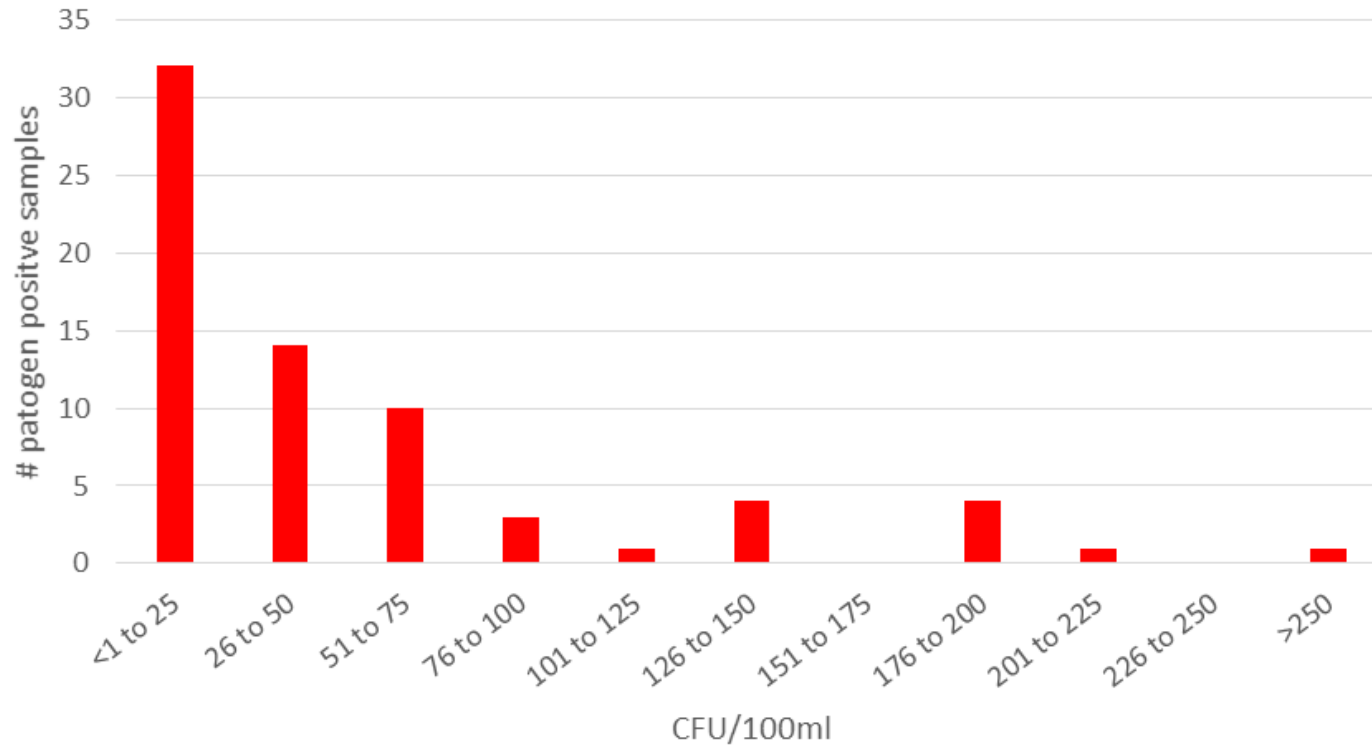
CFU/100 ml	Pathogen
130	Negative
130	Negative
130	EHEC
140	Negative
147	EHEC
150	EHEC
150	EHEC
170	Negative
173	Negative
180	Negative
180	Negative
190	EHEC

CFU/100 ml	Pathogen
192	EHEC
200	EHEC
206	Negative
210	Negative
220	Salmonella
>250	EHEC
>250	Negative
>250	Negative
>250	Negative
>250	Negative
>250	Negative
>250	Negative

- ▶ Of the 24 samples that exceeded the 126 cfu/100ml level, pathogens were only detected in 9 (8 below STV, 1 TNTC)
- ▶ Water management decision on no more than 7 of 2,160 samples (0.2%)

E. COLI COUNT VS. PATHOGEN PRESENCE

Generic E. coli Count vs. Pathogen Postive



- ▶ Of the 70 samples that pathogen were detected, none warranted a water management decision based on the generic *E. coli* count (with the exception of 1 that was TNTC)
- ▶ All water management decision based on the generic *E. Coli* count with respect to EHEC/O157/Sal 17 of 24 were wrong and 7 were TNTC
- ▶ All samples that contained EHEC/O157/Sal were cleared based on the generic *E. Coli* count (69 of 70, 1 TNTC)

E. COLI COUNT VS. PATHOGEN PRESENCE

- ▶ In 5-11 samples when the STV was exceeded, no pathogens were present and the water management decision was incorrect
- ▶ Out of the 5,460 samples tested, 85 had pathogens (1.6%) and in only 1 case, when the generic *E. coli* count was TNTC (>250), the water management decision may have been appropriate (0.02%). In the other 84 cases when pathogens were present, the water was cleared based on the generic *E. coli* count.
- ▶ The generic *E. coli* standard does not correlate with the presence of *Salmonella* or EHEC or *E. coli* O157

BOTTOM LINE

- ▶ Tiered System Based on Risk
 - ▶ Deep well
 - ▶ Shallow well
 - ▶ Surface water
 - ▶ Well head protection?
- ▶ Test for pathogens, e.g. *Salmonella* & EHEC
 - ▶ Where and when to test?
- ▶ If positive, qualify field and product
 - ▶ Retesting water
 - ▶ Robust field and product testing

MOVING FORWARD



APPENDIX A:
**Ag Water System Assessments and Remediation
Guidelines**



CA LGMA CHANGED THE WATER SECTION
OF THE METRICS (OCTOBER 24, 2019)

- ▶ Overhead applications (including irrigation, pesticide spray, aerial chemigation) applied within (<) 21 days of scheduled harvest date
- ▶ Tested before entering the 21-days-to-scheduled harvest timeframe
- ▶ Total coliform and generic *E. coli* in three (3)-100 mL samples
- ▶ No detectable generic *E. coli* in at least two (2) of the three (3) samples with a maximum level no greater than (<) 10 MPN in the remaining sample, and data monitoring and total coliform at a level no greater than (<) 99 MPN in 100 mL

LEAFY GREENS MARKETING AGREEMENT: DISTRIBUTION SYSTEMS, TYPE A

- ▶ Water that directly contacts edible portions of harvested crop or is used on food-contact surfaces such as equipment or utensils, must meet the Maximum Contaminant Level Goal for *E. coli* as specified by U.S. EPA or contain an approved antimicrobial treatment at a concentration sufficient to prevent cross-contamination.

LGMA DIRECT CONTACT: FOOD-CONTACT
(HARVEST), EQUIPMENT CLEANING &
SANITIZING, HYDROVAC COOLING, PRODUCT,
REHYDRATION, HYDROCOOLING

FIGURE 1. Irrigation Water from Type B Agricultural Water– See TABLE 2A

For any given water source (municipal, well, reclaimed water, reservoir or other surface water):

Sampling Frequency: One sample per water source shall be collected and tested prior to use if >60 days since last test of the water source. Additional samples shall be collected no less than 18 hr. apart and at least monthly during use.

- Sample sources as close to the point-of-use as practical using sampling methods as prescribed in Table 2A.
- Analyze samples for generic *E. coli* using a MPN methodology. Other EPA-, FDA- or AOAC International -accredited method may be used.
- Geometric means, including rolling geometric means shall be calculated using the five most recent samples.

Acceptance Criteria

≤ 126 MPN/100ml
(Geometric mean of 5 samples)
AND
≤576 MPN/100ml (all single samples)

No further action necessary. Water may be used in leafy green operations as outlined in Table 2A.

Action Level

> 126 MPN/100ml (geometric mean over five samples)
OR
>576 MPN/100ml (any single sample)

Remedial Actions:

- Discontinue any agricultural production use until it returns to compliance.
- Examine the water source and distribution system to determine if a contamination source is evident and can be eliminated.
- After remedial actions have been taken, retest the water at the same sampling point.
- Continue testing daily for five days at the point closest to use.
- If any of the next five samples is >576 MPN/ 100mL, repeat sanitary survey and/or remedial action.
- Do not use this water system until the water can meet the outlined acceptance criteria for this use.

Crop testing:

- If water exceeding the acceptance criteria has been used for crop production, sample and test product for STEC (including *E. coli* O157:H7) and *Salmonella* as described in Appendix C, prior to harvest.
- If crop testing indicates the presence of either pathogen, do NOT harvest for human consumption.

LGMA TYPE B: GROUND CHEMIGATION DRIP IRRIGATION, FURROW IRRIGATION, DUST ABATEMENT

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- ▶ 831.261.0076



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THANK YOU