

# Variations of Water Recycling Laws, Regulations, and Guidelines

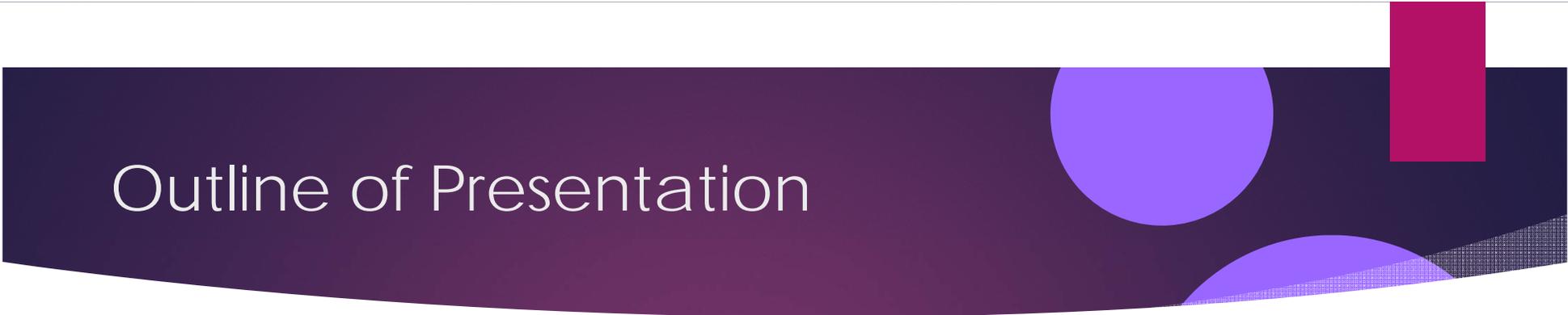


**BAHMAN SHEIKH**

MAY 27, 2015

WATER REUSE CONFERENCE

BOISE, IDAHO

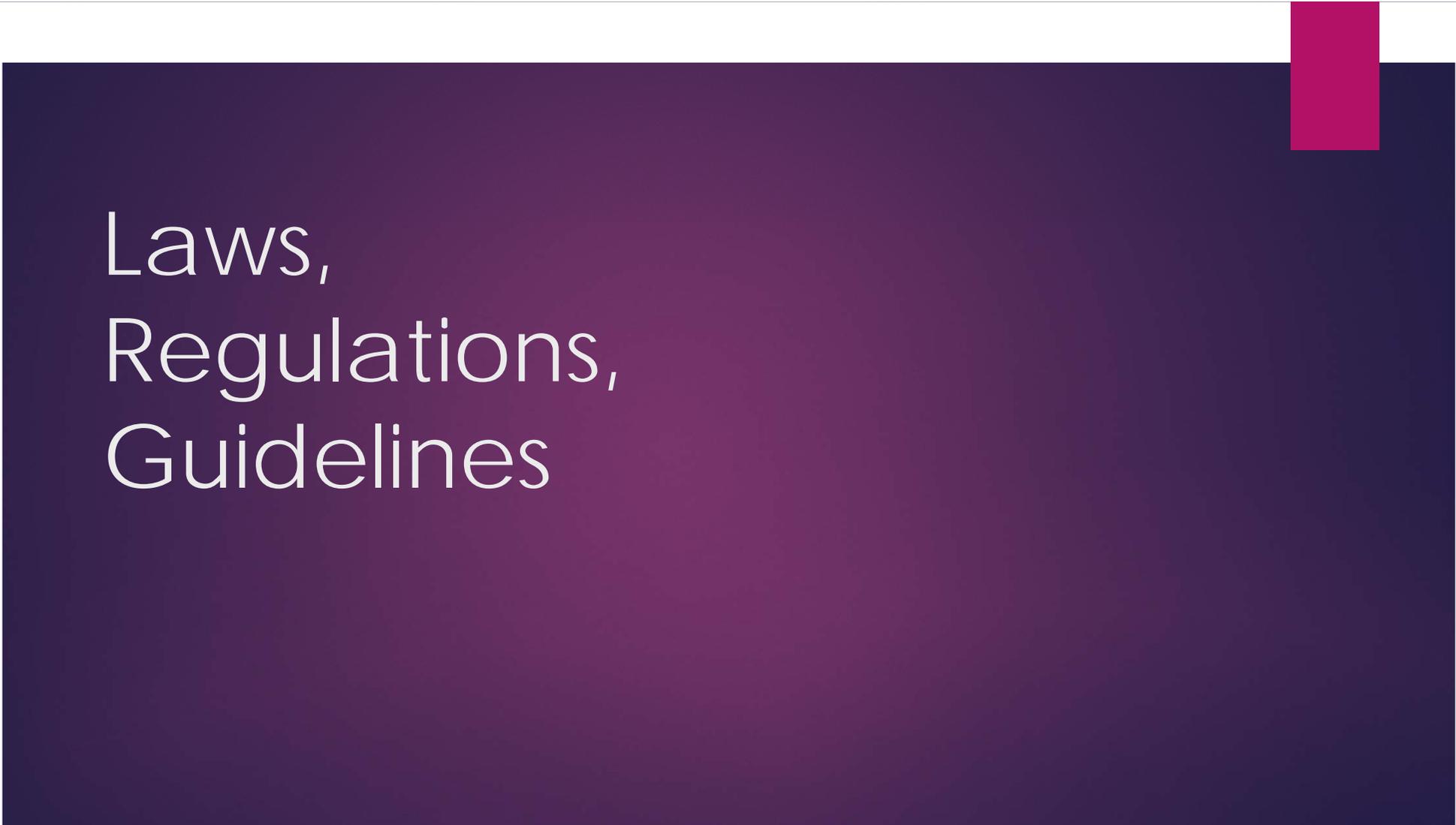


# Outline of Presentation

- ▶ Laws, Regulations, Guidelines
- ▶ Water Reuse, Then and Now
- ▶ Scope of Water Reuse Regulation
- ▶ Regulated Parameters
- ▶ Indicators of Contamination
- ▶ Global Perspective
- ▶ Variations in Regulations in the U. S. A.
- ▶ Conclusions and Recommendations







Laws,  
Regulations,  
Guidelines

# Laws, Regulations, Guidelines

## ▶ Laws

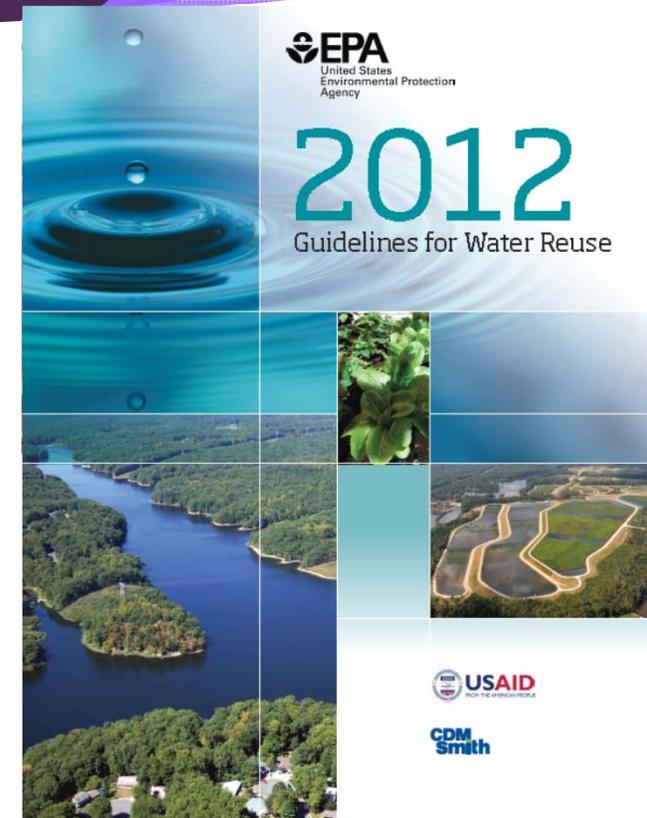
- ▶ Prohibitions
- ▶ Mandatory Use Requirements
- ▶ Incentivization, Grants, Tax Breaks, Drought Relief

## ▶ Regulations

- ▶ Prohibition
- ▶ Water Quality Requirements
- ▶ Use Area Restrictions, Signage, Training Requirements, Etc.

## ▶ Guidelines

- ▶ US EPA Water Reuse Guidelines
- ▶ WHO Guidelines



## Other Regulatory Regimes

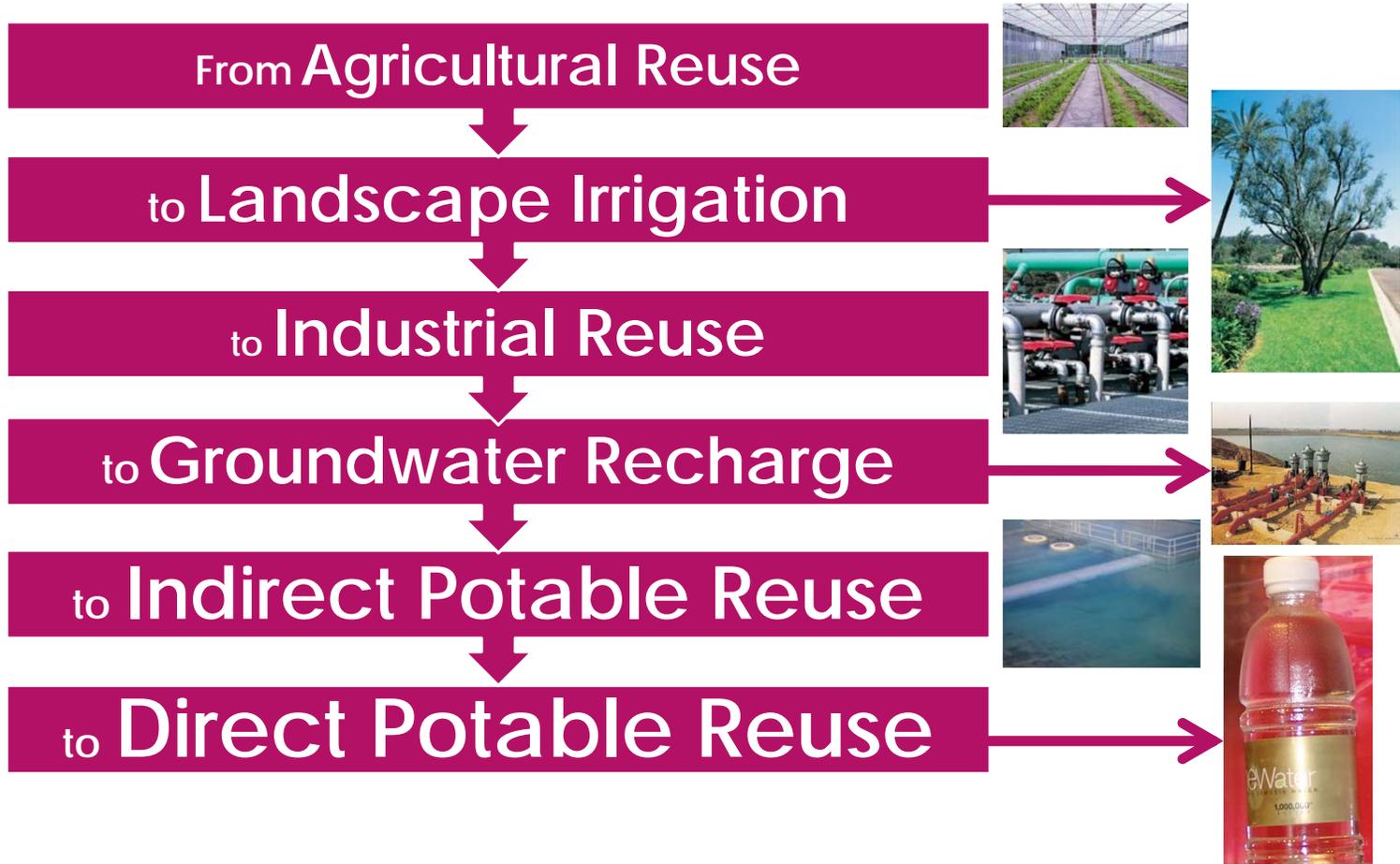
- ▶ Local (City, County Governments) Ordinances
- ▶ Plumbing Codes
- ▶ Water Purveyor Rules and Requirements
  - ▶ Water Department
  - ▶ Water District
  - ▶ Water Company
  - ▶ Wastewater Agency





# Water Reuse, Then and Now

# Evolution of Water Reuse:



# Non-Potable Uses of Recycled Water

- ▶ Irrigation
- ▶ Supply for Ponds, Pools, Fountains
- ▶ Cooling, Air Conditioning
- ▶ Toilet Flushing, Priming Drain Traps
- ▶ Commercial Laundries
- ▶ Construction Water Uses
- ▶ Industrial Boiler Feed
- ▶ Car Washing
- ▶ Fire Fighting
- ▶ Mixing Concrete
- ▶ Dust Control
- ▶ Street Cleaning
- ▶ Snow Making
- ▶ Flushing Sanitary Sewers



# Scope of Water Reuse Regulation

# Irrigation Uses of Recycled Water

- ▶ Non-Food Crops
- ▶ Food Crops (Trees, Nuts)
- ▶ Raw-Eaten Food Crops
  - ▶ Vegetables, Berries
- ▶ Root Crops, Tubers

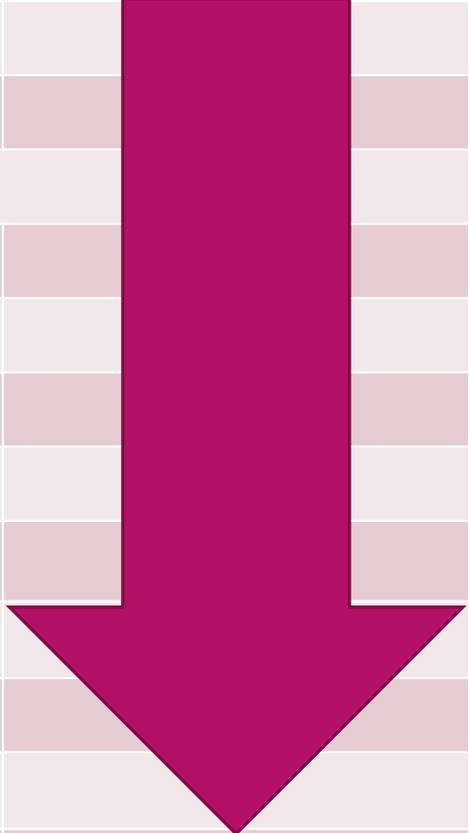
- ▶ Irrigation Method
  - ▶ Flood, Furrow
  - ▶ Sprinkler
  - ▶ Drip
  - ▶ Subsurface

# Regulated Parameters

- ▶ Water Quality
- ▶ Prescriptions for Treatment
- ▶ Site Controls
- ▶ Color Coding--Purple
- ▶ Distance from Wells
- ▶ Distance from Ponds
- ▶ Days Before Harvest
- ▶ Training of Field Workers

- ▶ Designation of Site Supervisor
- ▶ Inspections
- ▶ Cross-Connection Control
- ▶ Backflow Prevention
- ▶ Signage
- ▶ Disinfectant Residual
- ▶ Reporting
  - ▶ Annual
  - ▶ Violations

Type of Use of Recycled Water	Stringency of Regulation
Agriculture, Non-Food Crops (fodder, fiber, seed crops)	<b>Least Stringent</b>
Construction uses (soil compaction, dust control)	
Environmental reuse (wetlands, streamflow augmentation)	
Processed Food Crops (Commercial Processing to Destroy Pathogens)	
Industrial Reuse (Cooling Towers)	
Aquaculture	
Agricultural Irrigation of Food Crops with No Direct Contact	
Restricted Recreational Impoundments (Boating, Fishing)	
Restricted Urban Irrigation (Golf Courses, Roadway Medians)	
Unrestricted Urban Irrigation (Parks, Playgrounds, Residential)	
Unrestricted Urban Impoundments (Full-Body Contact)	
Agricultural Irrigation of Food Crops Eaten Raw with Direct Contact	
Potable Reuse	<b>Most Stringent</b>





# Regulated Parameters

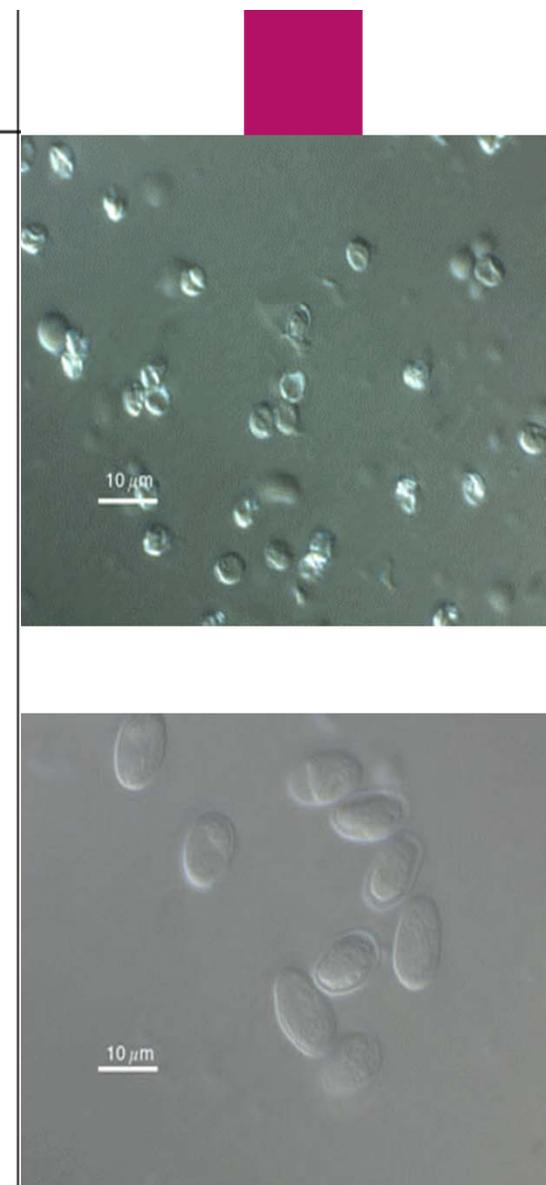
# Rationale for Regulation of Water Reuse

- ▶ Protection of Public Health—Primary Goal of Regulation
  - ▶ Pathogens
  - ▶ Chemicals
- ▶ Protection of the Environment
  - ▶ Nutrients
  - ▶ Disinfectant Residuals
  - ▶ Salts



Bacteria	Viruses	Protozoa
<p>Aerobacter</p> <p><i>Aeromonas hydrophila</i></p> <p>Campylobacter (including <i>C. jejuni</i>, <i>C. coli</i>, and related species)</p> <p><i>Helicobacter pylori</i></p> <p><i>Legionella</i> spp.</p> <p><i>Mycobacterium avium</i> complex</p> <p>Pathogenic <i>Escherichia coli</i></p> <p><i>Pseudomonas aeruginosa</i></p> <p><i>Yersinia enterocolitica</i></p>	<p>Adenoviruses</p> <p>Astrovirus</p> <p>Coxsackieviruses</p> <p>Echoviruses</p> <p>Enteroviruses</p> <p>Hepatitis viruses</p> <p>Norwalk/Caliciviruses</p> <p>Rotavirus</p>	<p><i>Acanthamoeba</i></p> <p><i>Cryptosporidium parvum</i></p> <p><i>Cyclospora cayetanensis</i></p> <p><i>Giardia lamblia</i></p> <p>Microsporidia</p> <p><i>Toxoplasma gondii</i></p>

Photo Credit: H.D.A. Lindquist, U.S. EPA



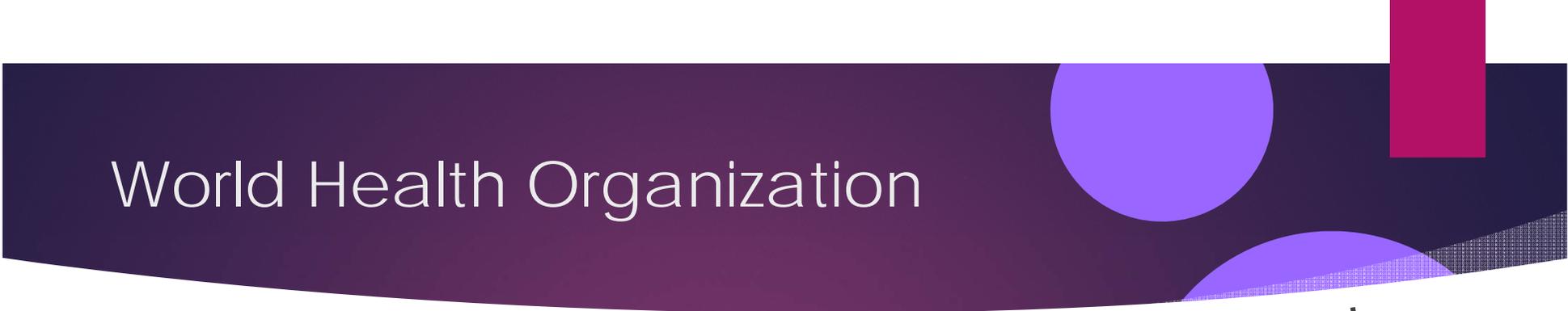


# Indicators of Contamination

# Removal of Contaminants via Measurement of Surrogates

- ▶ Microbial Indicators
  - ▶ **E.Coli**
  - ▶ Fecal Coliform
  - ▶ Total Coliform
  - ▶ Logs of Virus Removal
  - ▶ Eggs of Tapeworm

- ▶ Plant Performance Indicators
  - ▶ **Turbidity**
  - ▶ Biochemical Oxygen Demand
  - ▶ Suspended Solids



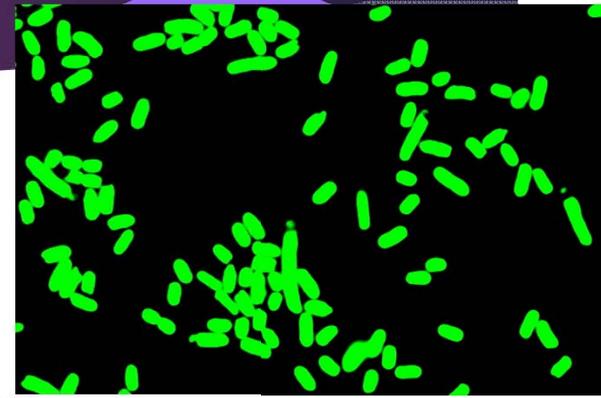
World Health Organization

**“Escherichia coli and to a lesser extent thermotolerant coliform bacteria are considered to best fulfill the criteria to be satisfied by an ideal indicator.”**

SOURCE: WHO, Guidelines, Standards and Health: Assessment of risk and risk management for water-related infectious disease, p. 20.

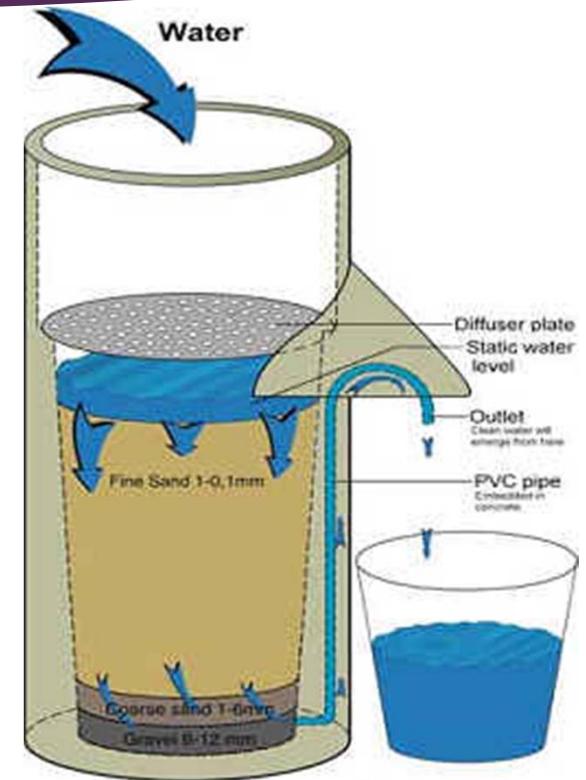
# Microbial Indicators of Pathogen Kill

- ▶ Total, Fecal, Escherichia Coliforms
- ▶ Equivalent Indicators of Presence/Absence of Pathogens
- ▶ Accepted and Used World-wide
- ▶ Europe Uses E. Coli, as does Australia, and WHO
- ▶ Wide Range of Numerical Standards in Different Jurisdictions
- ▶ Choice of Indicator is Based on Historical Practice, Level of Comfort, and ... Habit



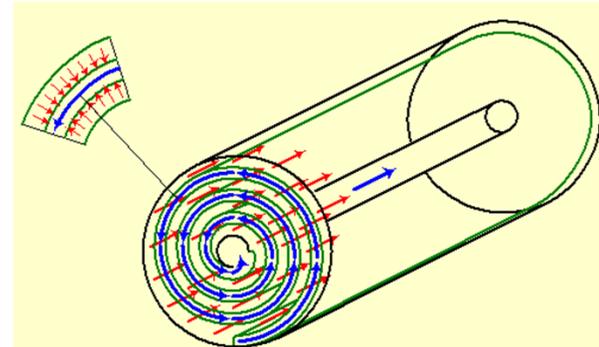
# Treatment for removal/inactivation of Microbes

- ▶ Protozoans
  - ▶ Filtration
- ▶ Bacteria
  - ▶ Filtration and Disinfection
- ▶ Viruses
  - ▶ Coagulation/Sedimentation, Filtration and Disinfection



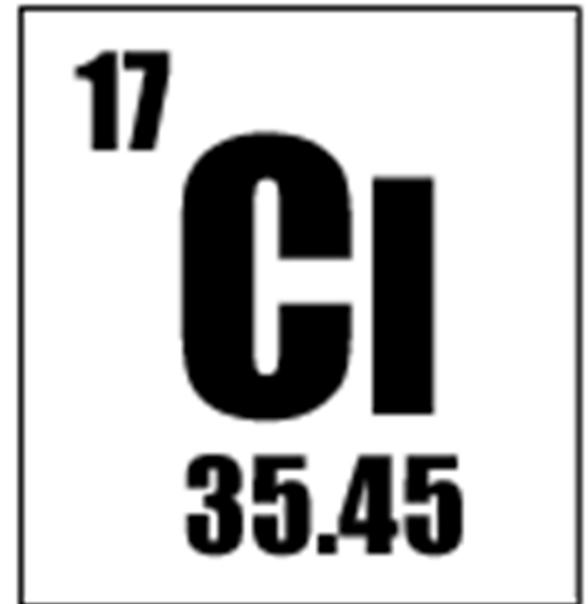
# Treatment for Removal of Chemicals

- ▶ Heavy Metals
  - ▶ Removed in Sludges
- ▶ Nutrients
  - ▶ Biological Nutrient Removal—if Needed
  - ▶ Beneficial for Irrigation of Food Crops—Not Necessary for Irrigation
- ▶ Microconstituents
  - ▶ Reverse Osmosis—where Needed
  - ▶ Not Necessary for Irrigation



# Disinfectant, Chlorine

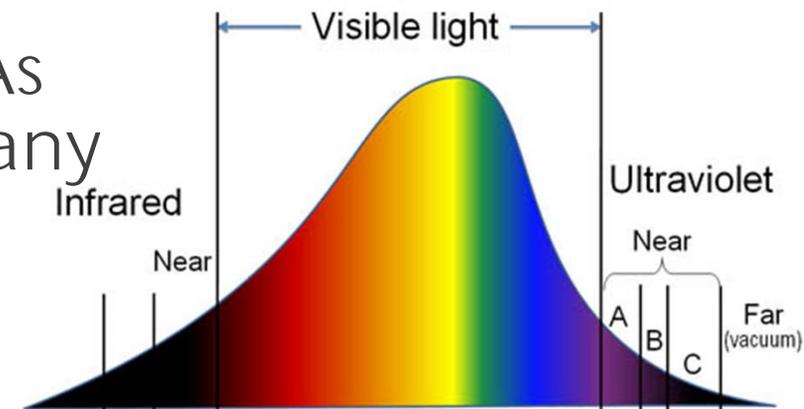
- ▶ Chlorine
  - ▶ gaseous chlorine
  - ▶ Hypochlorite
  - ▶ Chloramines
  - ▶ Chlorine Dioxide

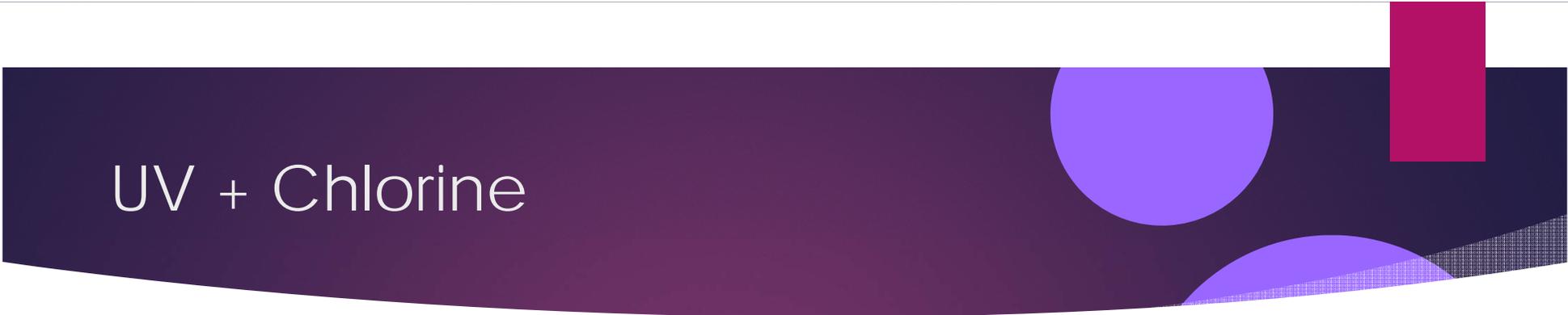


# Disinfectant, UV

## ▶ Ultraviolet Light

- ▶ Cost-competitive with Chlorine
- ▶ Safer To Use and Transport
- ▶ No Hazardous Disinfection Byproducts
- ▶ Effective Against Parasites Such As *Cryptosporidium*, *Giardia* And Many Bacteria.
- ▶ Chlorine for Residual



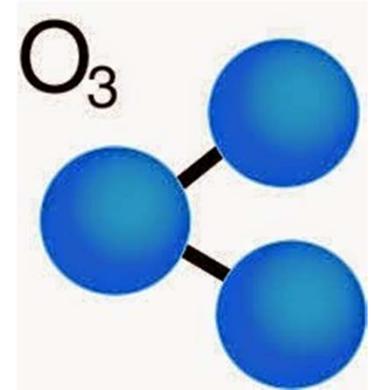


## UV + Chlorine

- ▶ Where UV is used for disinfection, chlorine is often added to the reclaimed water prior to its entrance to a pipeline distribution system to prevent microbial regrowth, reduce the formation of biological growths and slimes in pipelines, and to oxidize organic matter to prevent odors.

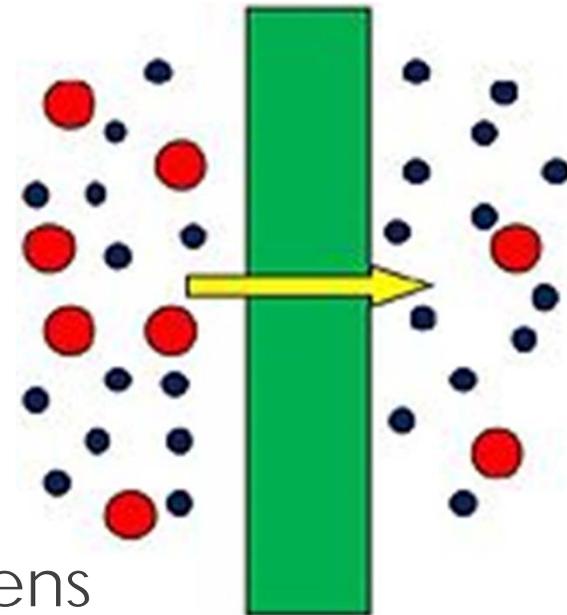
## Disinfectant, O<sub>3</sub>

- ▶ Powerful Oxidant
- ▶ Removes Organic Compounds
- ▶ Removes Color
- ▶ Oxidizes Potentially Toxic Chemicals To Non-hazardous Substances.
- ▶ High Operation and Maintenance Costs



# Disinfectant, Membranes

- ▶ Remove Some Pathogens
  - ▶ Size Exclusion
- ▶ Microfiltration Effectively Removes
  - ▶ *Cryptosporidium*
  - ▶ *Giardia*
  - ▶ Many Bacteria
- ▶ Reverse Osmosis Can Remove All Pathogens From The Water, Including Viruses





# Global Perspective

# International Standards, Regulations

- ▶ World Health Organization (WHO)
- ▶ USA and Individual States
- ▶ Europe
- ▶ Japan
- ▶ Australia
- ▶ South Africa
- ▶ Middle East/North Africa
- ▶ Mexico
- ▶ India



# Disinfection for Unrestricted Irrigation (Vegetables Eaten Raw)

Country, Region	Total Coliform/100 mL	Fecal Coliform/100 mL
<b>Colorado, New Mexico, Texas</b>	Prohibition of Use	
Italy, Puglia, Emilia Romagna	$\leq 2$	
USEPA (G), <b>Arizona, Utah</b> , Japan, UK		No Detect
<b>California, Washington</b>	$\leq 2.2$	
Germany, Victoria, Australia (National Guidelines)		$\leq 10$
Spain		$\leq 200$
France, Sicily, Greece, Mexico, Mediterranean Region		$\leq 1000$

# Disinfection for “Restricted” Irrigation (Processed Food, Orchards, Pasture)

State, Country, Region	Total Coliform /100 mL	Fecal Coliform /100 mL
Puglia (S. Italia)	≤ 10	
<b>California</b> , Italy, Emilia Romagna	≤ 23	
Australia		≤ 10
Germany	≤ 100	≤ 10
Washington	≤ 240	
<b>Florida, Utah, Texas, USEPA (G)</b>		≤ 200
<b>Arizona, New Mexico</b> , Australia, Victoria, Sicily, Mexico, Greece, Spain		≤ 1,000
Austria		≤ 2,000
Sicily	≤ 3,000	
Cyprus		≤ 3,000
		≤ 10,000

# Disinfection for Irrigation of Urban Parks, Cemeteries, Playgrounds, Athletics Fields

Country, Region	Total Coliform /100 mL	Fecal Coliform /100 mL
Arizona, Florida, Utah		No Detect
California, Washington	$\leq 2.2$	
New Mexico		$\leq 5$
Texas		$\leq 20$
Greece		$\leq 100$
Colorado (EC),		$\leq 126$
Spain		$\leq 200$
France		$\leq 1,000$

# Disinfection for Potable Groundwater Recharge (Injection into the Aquifer)

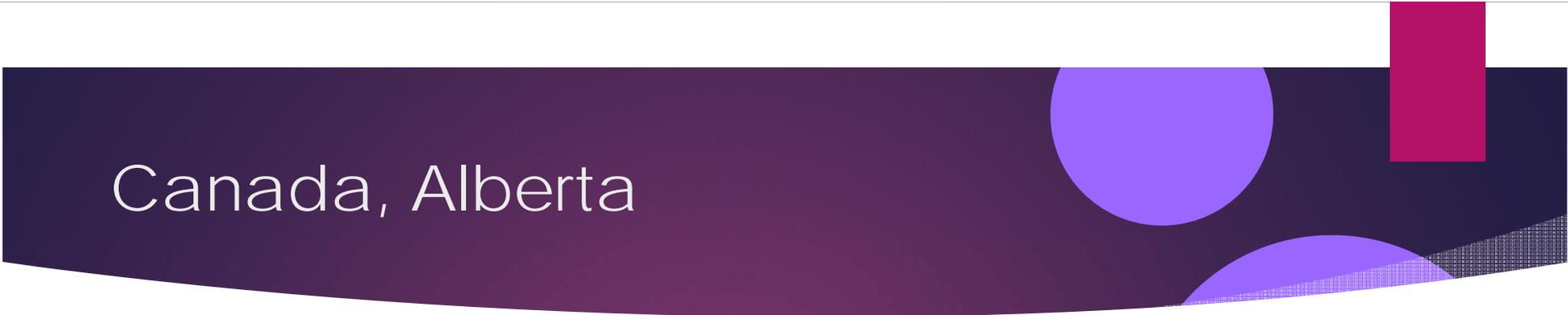
Country, Region	Total Coliform /100 mL	Fecal Coliform /100 mL
<b>USEPA Guidelines, Florida, Spain</b>		No Detect
<b>California</b> (+ 5-Log Virus Deactivation)	$\leq 2.2$	
Greece		$\leq 5$
Germany	$\leq 100$	$\leq 10$
Australia		$\leq 10$

# Disinfection for Groundwater Recharge (Spreading Basins)

Country, Region	Total Coliform /100 mL	Fecal Coliform /100 mL
<b>Florida</b>		No Detect
<b>California</b> (+ 5-Log Virus Deactivation)	$\leq 2.2$	
Germany, Australia	$\leq 100$	$\leq 10$
Spain		$\leq 1,000$

# Israel

- ▶ Disinfection of the effluent is necessary barrier for irrigation of raw-eaten vegetables
- ▶ Disinfection system must include:
  - ▶ Continuous control of total residual chlorine
  - ▶ Recording/reporting of data
  - ▶ Connection to effluent supply system
- ▶ No Numerical Limits in Regulations



## Canada, Alberta

- ▶ <1,000 total coli/100 mL, and <200 fecal coli/100 mL for both unrestricted and restricted urban and agricultural irrigation

# Florida—Potable Reuse

Type of Use	Fecal Coliform	TSS	TOC, BOD	NO <sub>3</sub>
RIBS	0	5	--	--
Injection in GW	0	5	--	--
Injection in Biscayne	0	5	3 (TOC)	--
Injection to Surface Water	0	5	20 (CBOD)	10

# USEPA Guidelines

Type of Use	Fecal Coliform/100 mL	Treatment
Urban, Vegetables, Ponds	No detectable	2 <sup>nd</sup> , F, D
Restricted Irrigation Industrial, Environmental	<200	2 <sup>nd</sup> , D
GW Recharge, non-potable	Site Specific	2 <sup>nd</sup> , site-specific
GW Recharge, spreading, potable	Site Specific	2 <sup>nd</sup> , D, may need F
GW Recharge, Injection, Surface Water	No detectable	2 <sup>nd</sup> , F, D, Adv

# Potable Reuse "Regs", Guidelines

	Virus	Bacteria	Giardia	Crypto
California (from raw wastewater)	12	--	10	10
Texas (from secondary effluent)	8	--	6	5.5
NWRI (from raw wastewater)	12	9	--	10

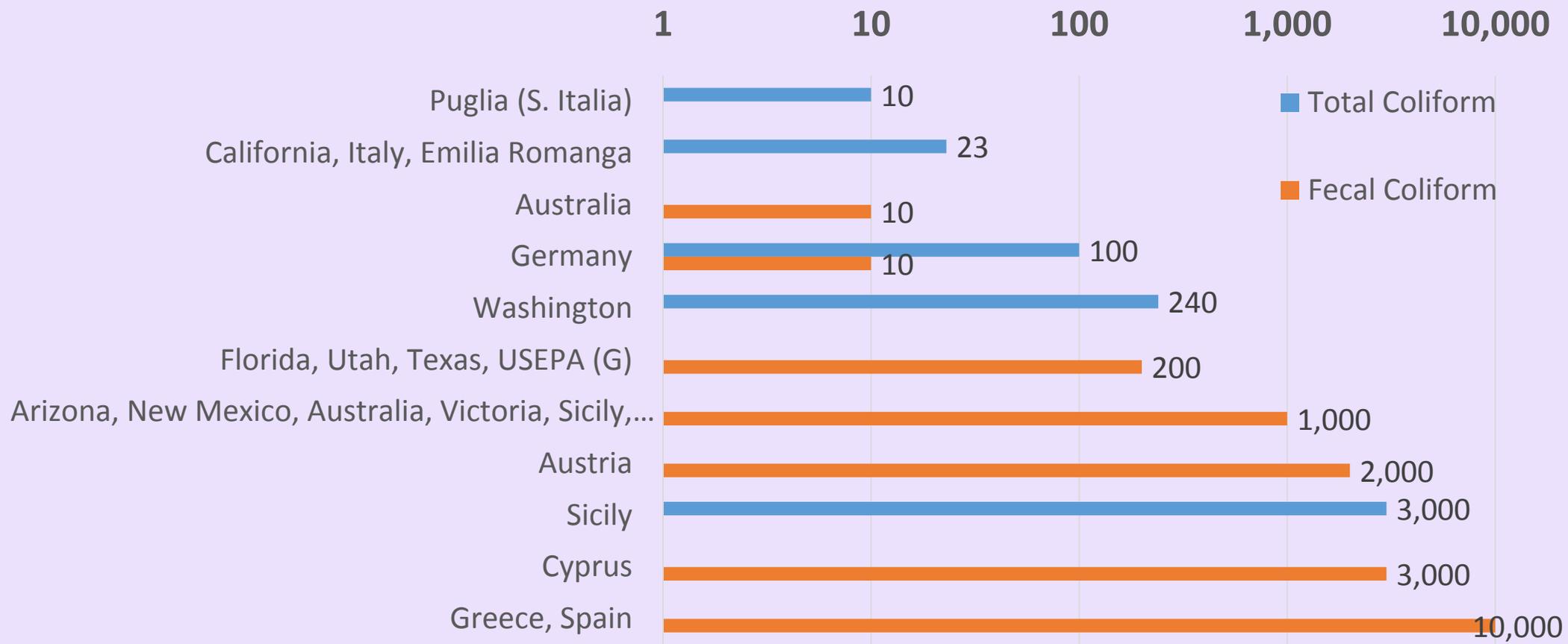


# Variations in Regulations in the U. S. A.

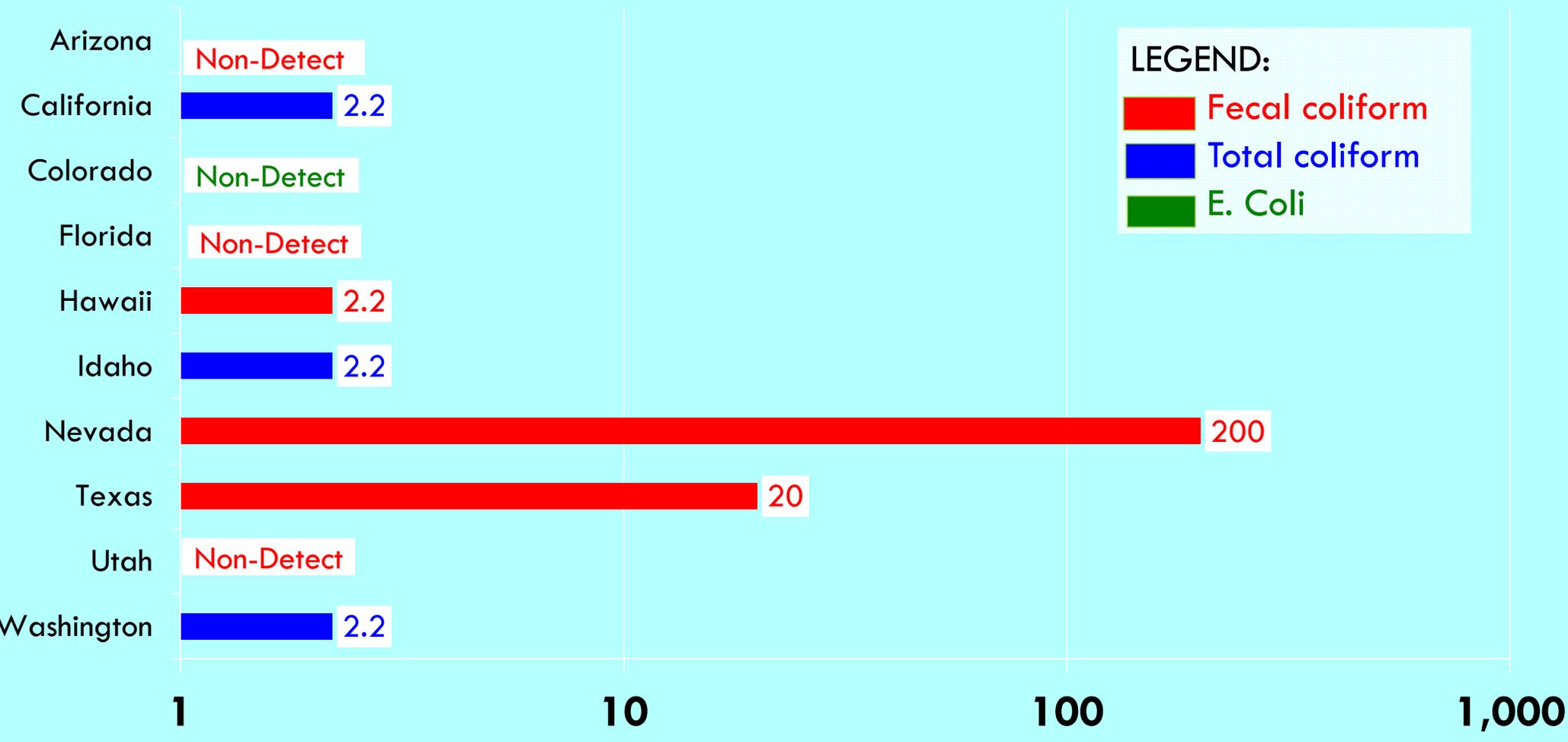
# Comparison of US States' regulations

Requirement	Arizona	California	Colorado	Florida	Hawaii	Nevada	Texas	Utah	Washington
<b>Treatment Train</b>	Secondary treatment, filtration, disinfection	Oxidized, coagulated, filtered, disinfected	Not covered	Secondary treatment, filtration, disinfection	Oxidized, filtered, disinfected	Secondary treatment, disinfection	NS*	Secondary treatment, filtration, disinfection	Oxidized, coagulated, filtered, disinfected
<b>BOD5</b>	NS	NS	Not covered	20 mg/l	NS	30 mg/l	5 mg/l	10 mg/L	30 mg/l
<b>TSS</b>	NS	NS	Not covered	5 mg/l	NS	NS	NS	NS	30 mg/l
<b>Turbidity</b>	2 NTU	2 NTU	3 NTU (Max)	NS	2 NTU (Max)	NS	3 NTU	2 NTU	2 NTU (Avg)
	5 NTU (Max)	5 NTU (Max)							5 NTU (Max)
<b>Coliform</b>	<b>Fecal</b>	<b>Total</b>	<b>E. Coli</b>	<b>Fecal</b>	<b>Fecal</b>	<b>Fecal</b>	<b>Fecal</b>	<b>Fecal</b>	<b>Total</b>
	None detectable (Avg)	2.2/100ml (Avg)	Non-Detect	75% of samples below detection	2.2/100 ml (Avg)	200/100 ml (Avg)	20/100 ml (Avg)	None detectable	2.2/100 ml (Avg)
	23/100 ml (Max)	23/100 ml (Max in 30 days)	126/100 mL	25/100 ml (Max)	23/100ml (Max in 30 days)	400/100 ml (Max)	4 enterococci (100 ml) 75/100 ml (Fecal max)		NS

# Global Microbial Indicator Limits for Recycled Water (Restricted Use) Microbial Criteria



# U.S. MICROBIAL INDICATOR LIMITS FOR RECYCLED WATER (UNRESTRICTED USE) MICROBIAL CRITERIA





# Conclusions and Recommendations

## CONCLUSIONS

- ▶ Safety of Water Reuse Under Regulations Has Been Amply Demonstrated
  - ▶ Even with the Least Stringent Standards
- ▶ Uniform Water Reuse Regulation Is A Pipedream
- ▶ There are Great Variations in State Regulations;
  - ▶ All Providing Safe Recycled Water for All Uses
    - ▶ Even for Potable Reuse

# Recommendations

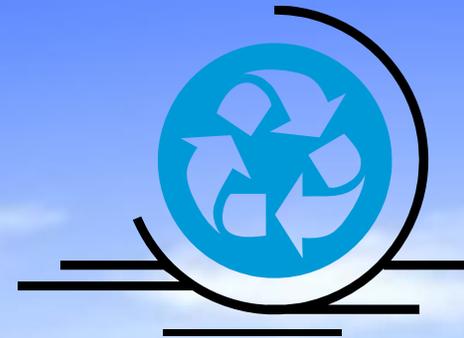
- ▶ We Have Learned A Great Deal about Safety of Recycled Water
- ▶ Time to Take the Training Wheels Off
- ▶ Regulate Water Reuse with Trust—Not with Fear
- ▶ Provide for Water Quality
  - ▶ Not by Prescribing Treatment Details
  - ▶ By Specifying End-Point Water Quality Standards
  - ▶ By Requiring Real-Time Monitoring, Reliability, Record Keeping, Reporting
- ▶ Empower Water Purveyors to Protect the Safety of their Customers
  - ▶ Unblemished Record of Clean, Safe Water
  - ▶ Stewards of the Environment



**Thanks for  
Your  
Attention**



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