Water Quality Assessment for Direct Potable Reuse

R.Rhodes Trussell

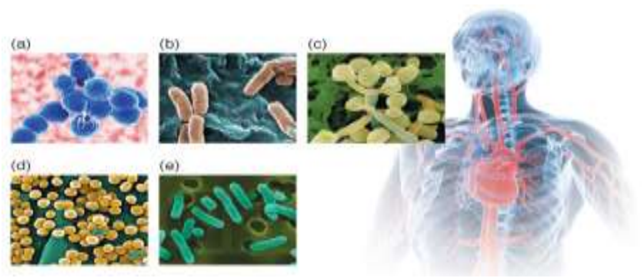
Chairman & Founder, Trussell Technologies, Inc.

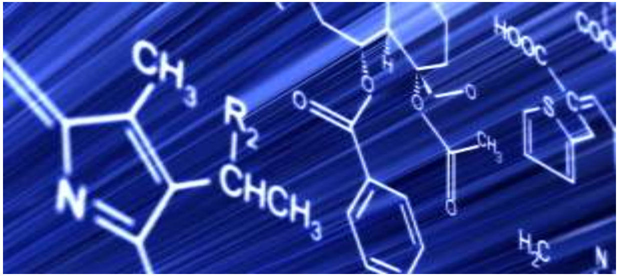
Annual NWRI Clarke Prize Conference

November 4, 2016

Let’s take a closer look from the perspective of our most important categories of water quality

- Pathogens & Chemicals

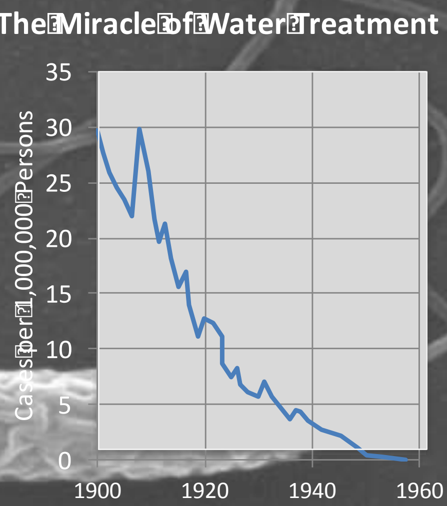




www.bacteriainphotos.com

We Believe the Most Important Issue in Potable Reuse is Waterborne Disease

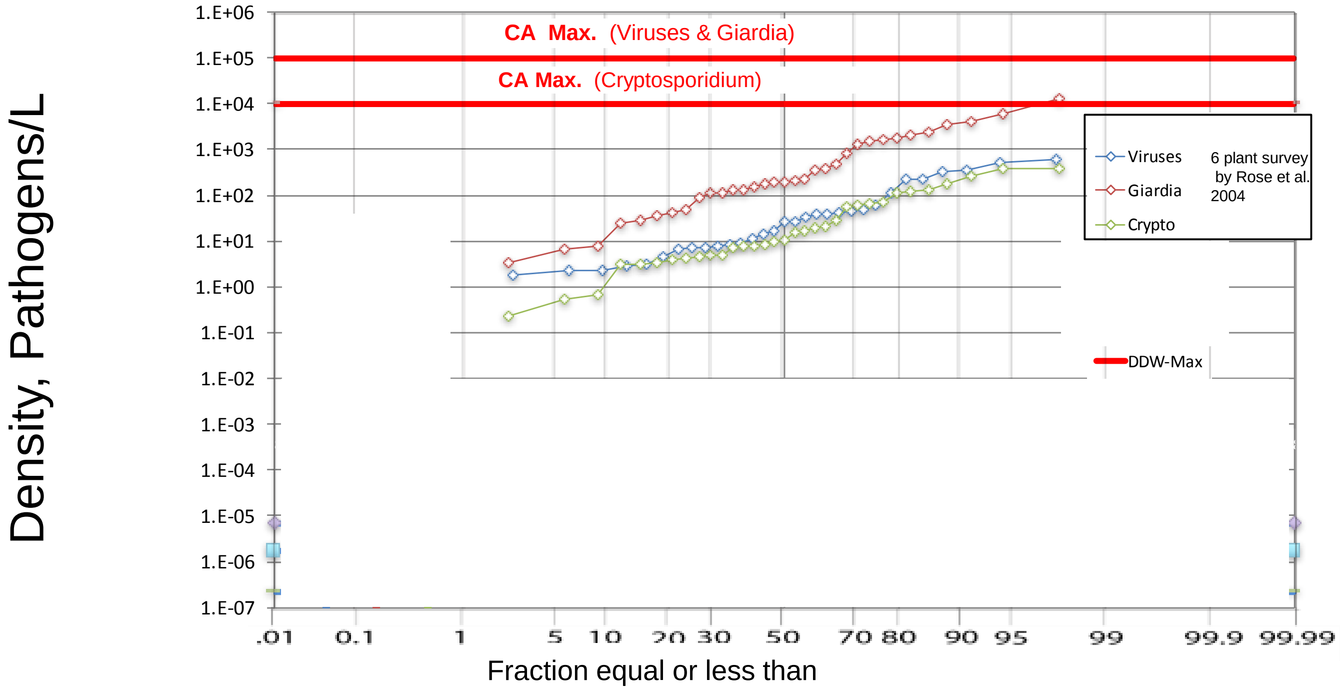
Thanks to John Snow



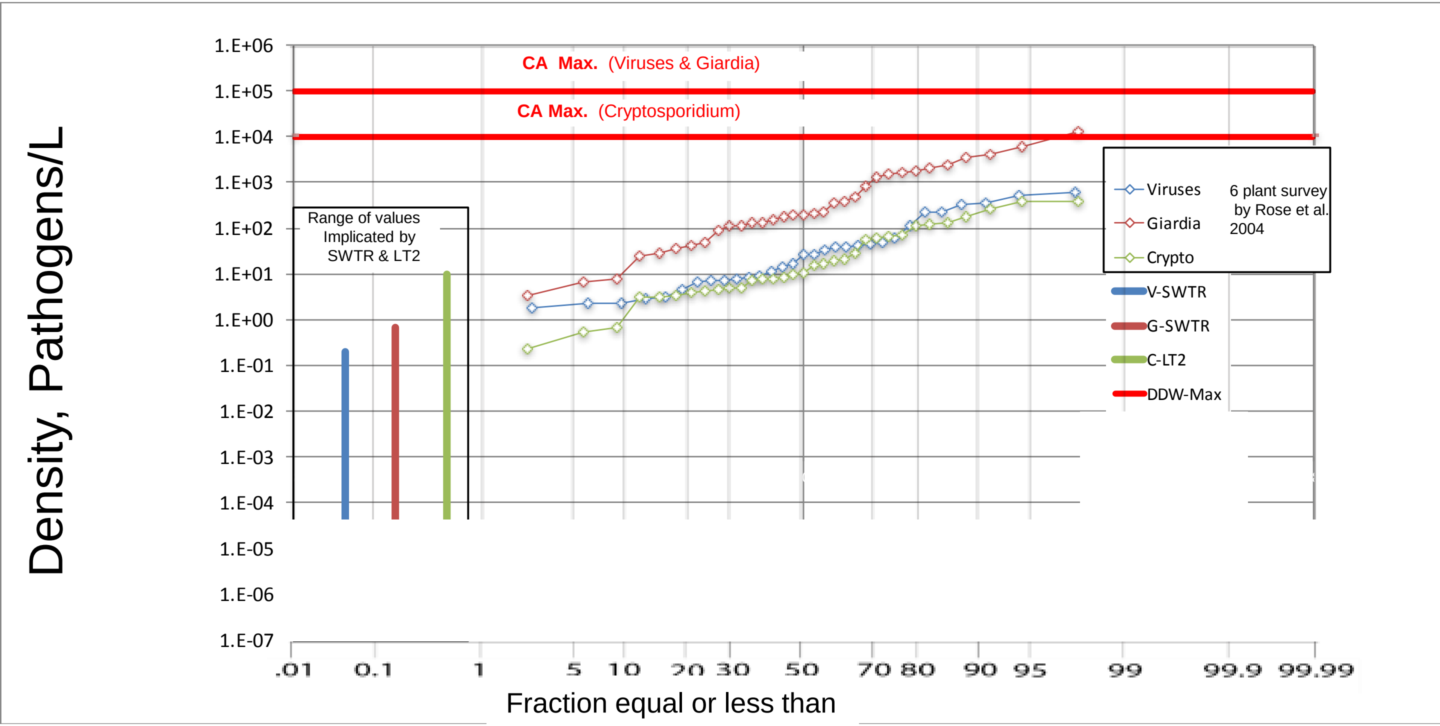
Dartmouth Electron Microscope Facility/Louisa Howard

Vibrio cholerae

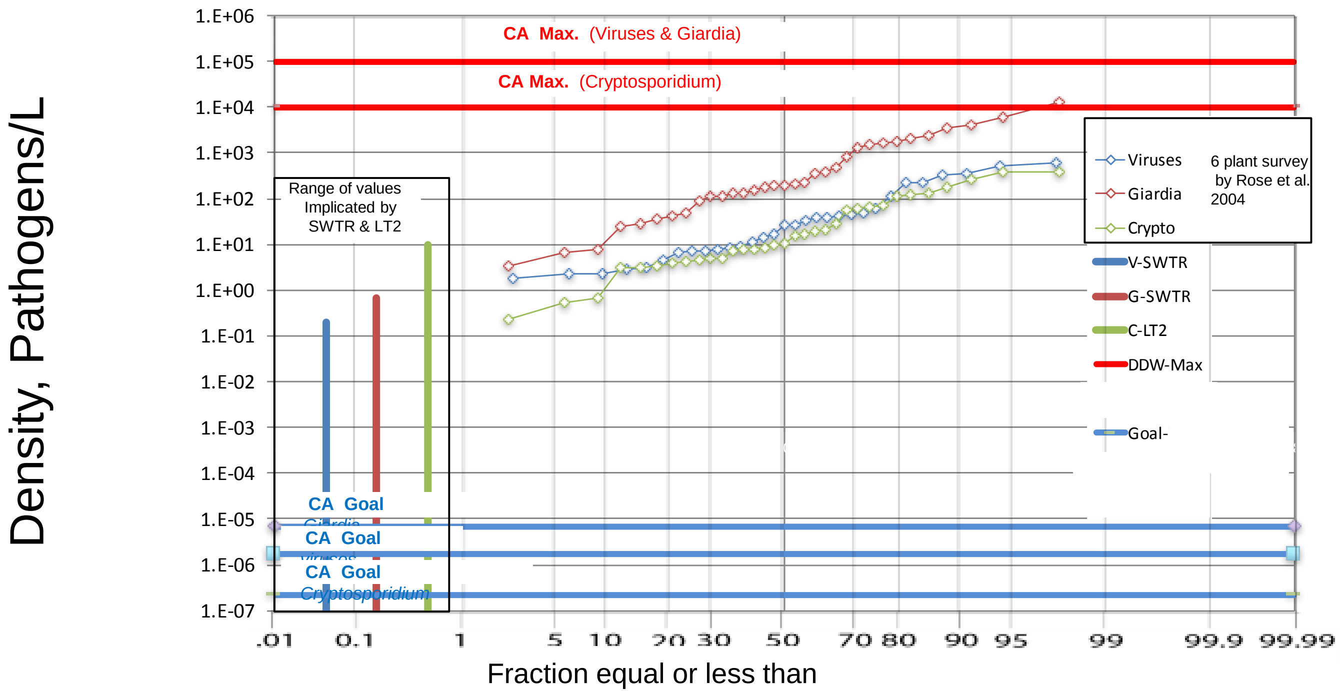
Getting Perspective on Risk of Gastrointestinal Disease



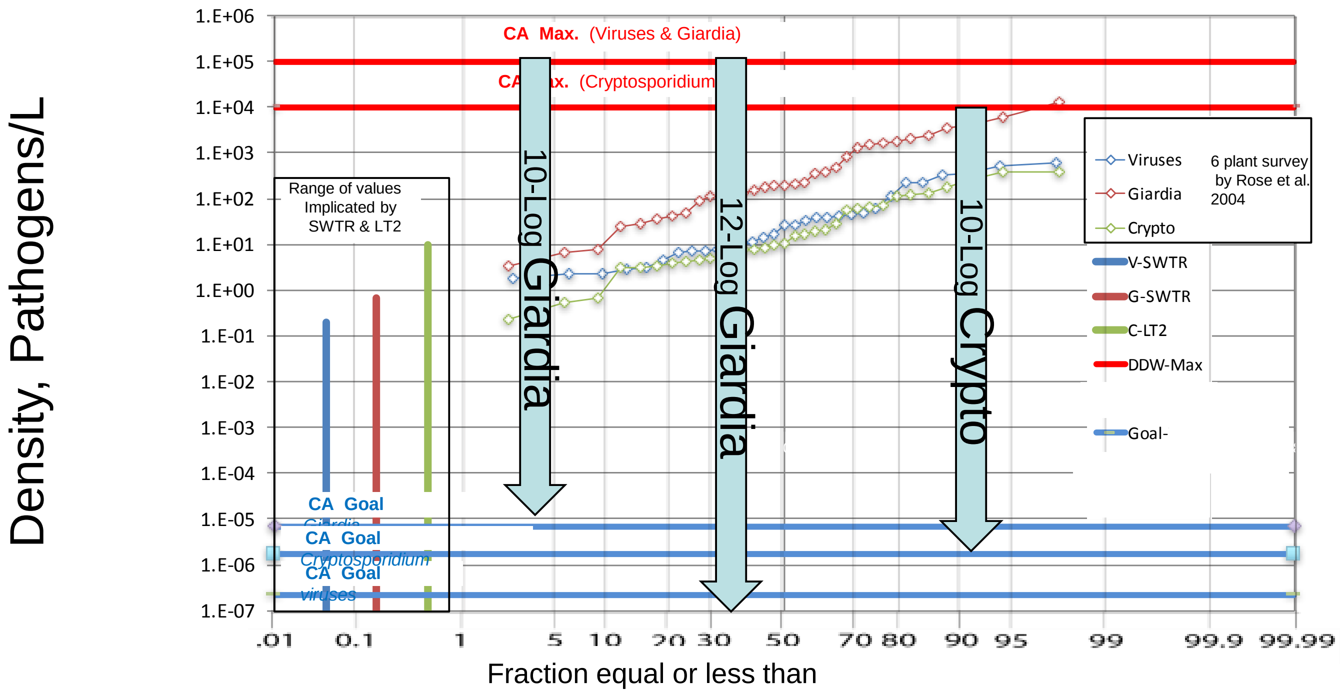
Getting Perspective on Risk of Gastrointestinal Disease



Getting Perspective on Risk of Gastrointestinal Disease

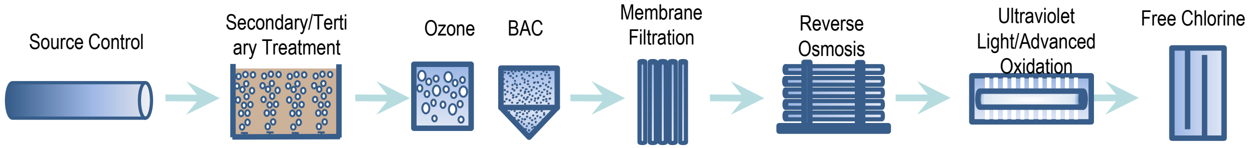


Getting Perspective on Risk of Gastrointestinal Disease

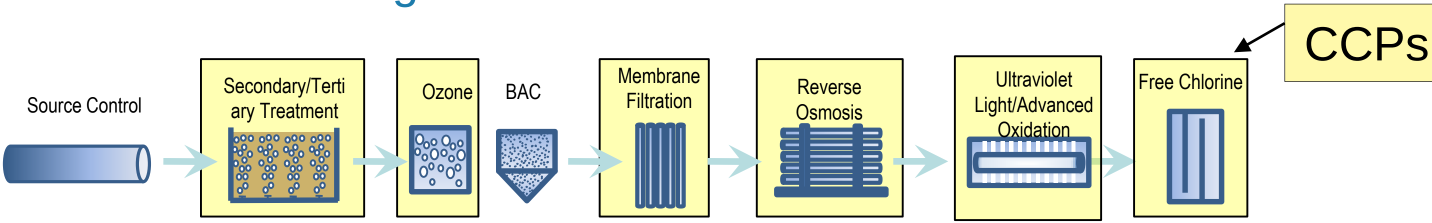


Assessing the control of pathogens

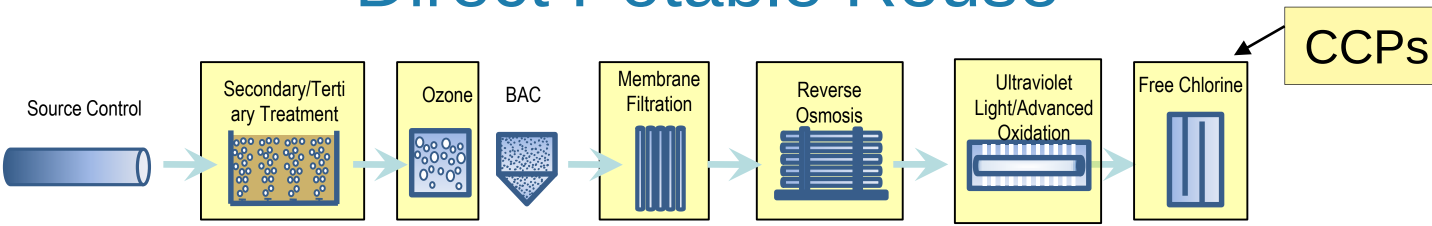
Pathogen Control in Direct Potable Reuse



Pathogen Control in Direct Potable Reuse

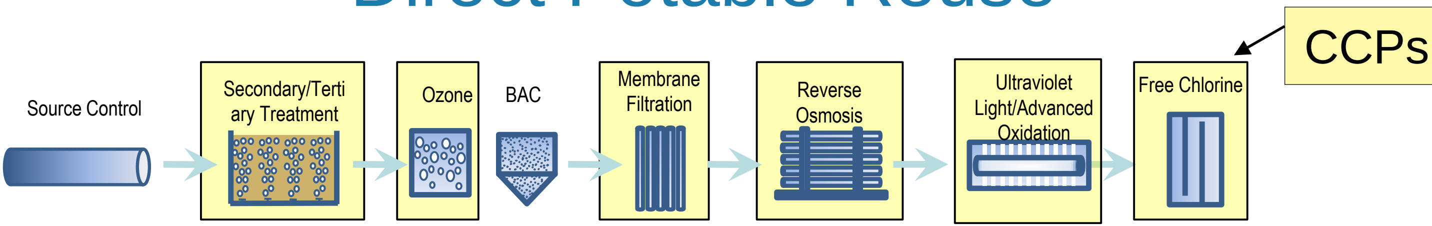


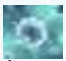
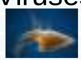
Assessing Pathogen Control in Direct Potable Reuse



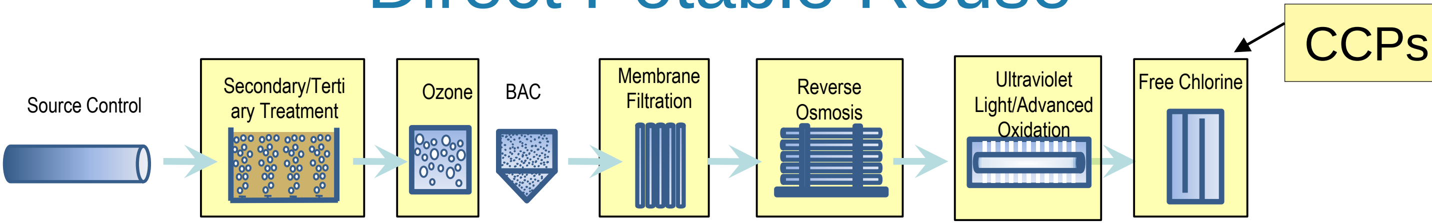
	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV
Viruses	Turb	1.9 to 2.2	Ct	> 6	-	-	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6
Giardia	Turb	0.8 to 2.2	Ct	> 6	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6
Cryptosporidium	Turb	1 to 1.5	Ct	1 to 2	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6		

Assessing Pathogen Control in Direct Potable Reuse



	Secondary/Tertiary Treatment Surrogate	LRV	Ozone Surrogate	LRV	Membrane Filtration Surrogate	LRV	Reverse Osmosis Surrogate	LRV	UV/AOP Surrogate	LRV	Free Chlorine Surrogate	LRV	Total LRV	DDW Minimum
 Viruses	Turb	1.9 to 2.2	Ct	> 6	-	-	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6	20 to 22	12
 *Giardia*	Turb	0.8 to 2.2	Ct	> 6	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6	23 to 26	10
 *Cryptosporidium*	Turb	1 to 1.5	Ct	1 to 2	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6			13 to 15.5	10

Assessing Pathogen Control in Direct Potable Reuse



	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	Surrogate	LRV	**Total LRV**	**DDW Minimum**
 Viruses	SS	1.9 to 2.2	Ct	> 6	-	-	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6	**20 to 22**	**12**
 *Giardia*	SS	0.8 to 2.2	Ct	> 6	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6	Ct	6	**23 to 26**	**10**
 *Cryptosporidium*	SS	1 to 1.5	Ct	1 to 2	PDT	4	EC/TOC	1 to 2	UVT>95% EED	6			**13 to 15.5**	**10**

14-12 Process train as an example … *we know how to do this*

Chemicals

Chemicals

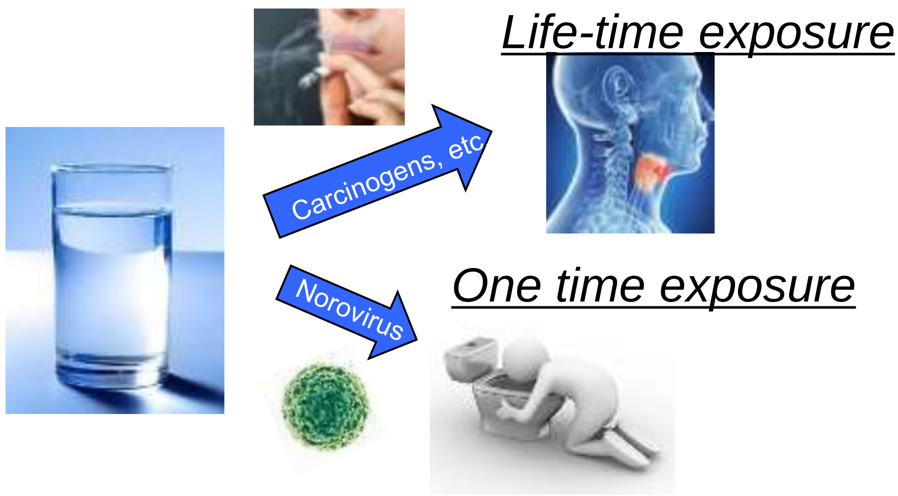
1. Toxic chemicals (e.g. 129 priority pollutants)
2. Trace Organics: CECs Pharmaceuticals, personal Care Products, etc.
3. Dissolved organic matter – TOC, NOM, EfOM
4. Transformation products (esp. DBPs)

Chemicals

1. *Toxic chemicals (e.g. 129 priority pollutants)*
2. Trace Organics: CECs Pharmaceuticals, personal Care Products, etc.
3. Dissolved organic matter – TOC, NOM, EfOM
4. Transformation products (esp. DBPs)

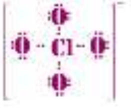
The Significance of Time of Exposure: Chemicals vs Pathogens

- At the levels found in used water:
  - Pathogens often cause effects following just one exposure
  - But chemicals only have effects after prolonged Exposure



The Significance of Time of Exposure: "Acute" chemicals vs Pathogens

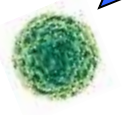
Even the "acute" effects from chemicals found in used water occur over a different time-scale of exposure



Perchlorate

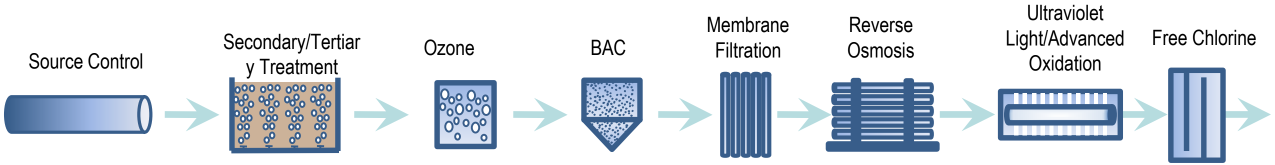
Exposure, 30-d+

Norovirus

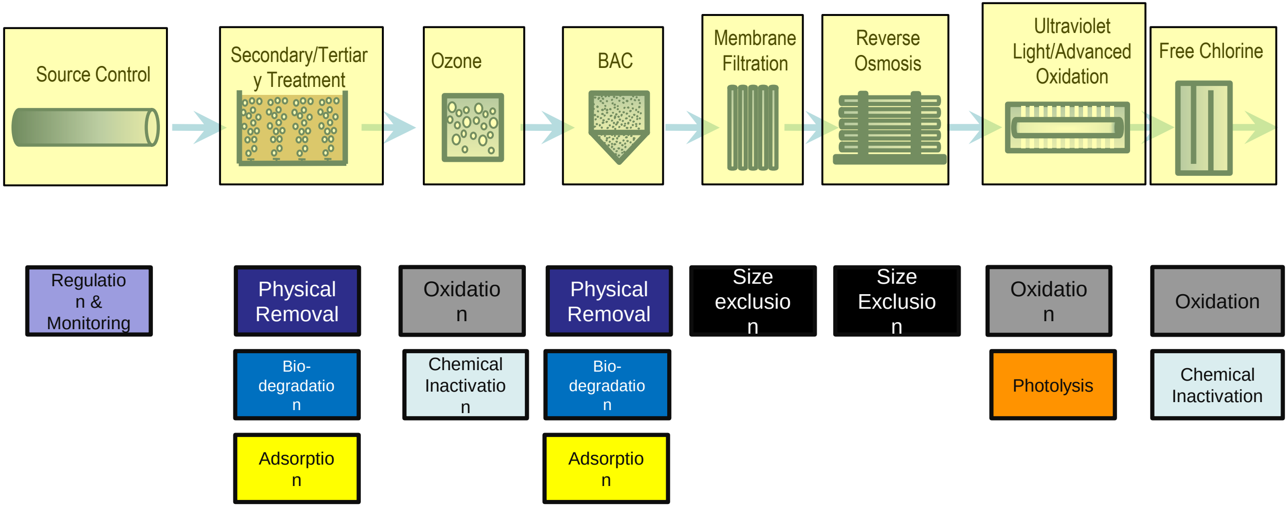


One time exposure

Control of Chemicals in Direct Potable Reuse

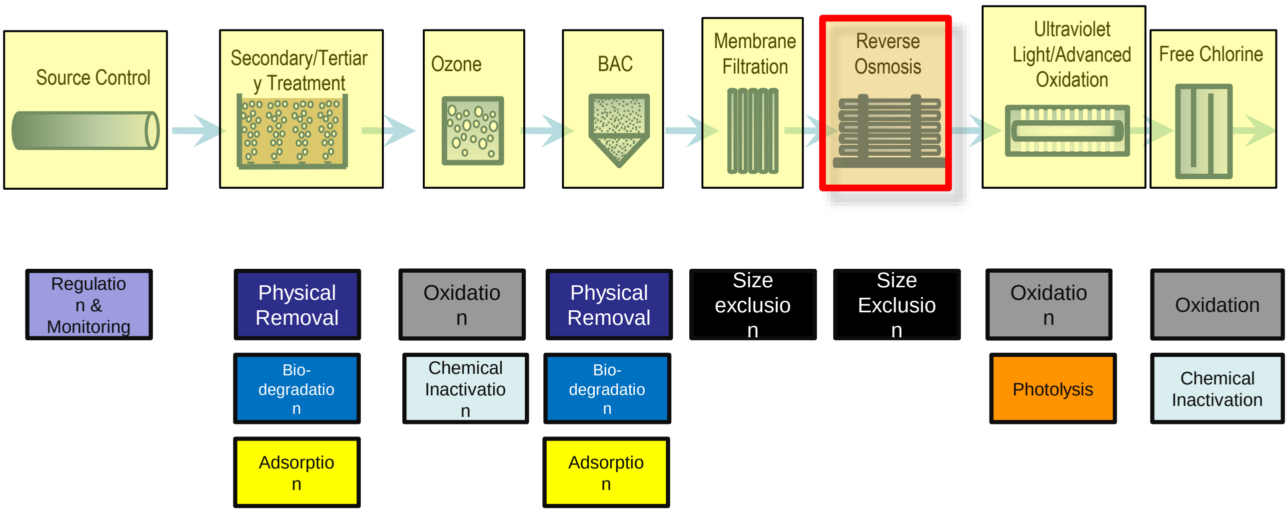


Control of Chemicals in Direct Potable Reuse



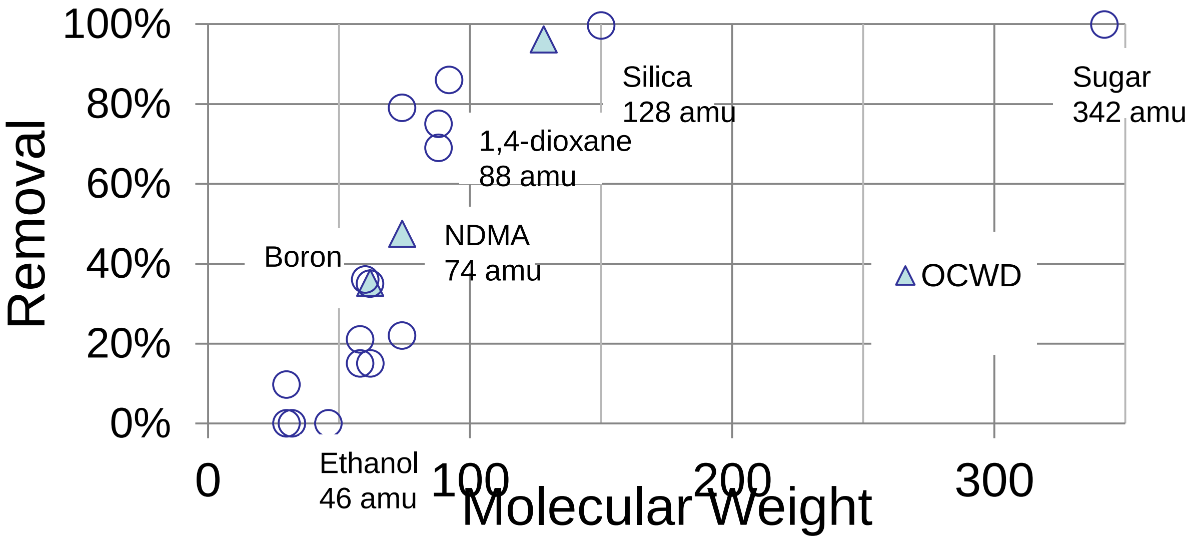
There are a lot of tools in play

Control of Chemicals in Direct Potable Reuse

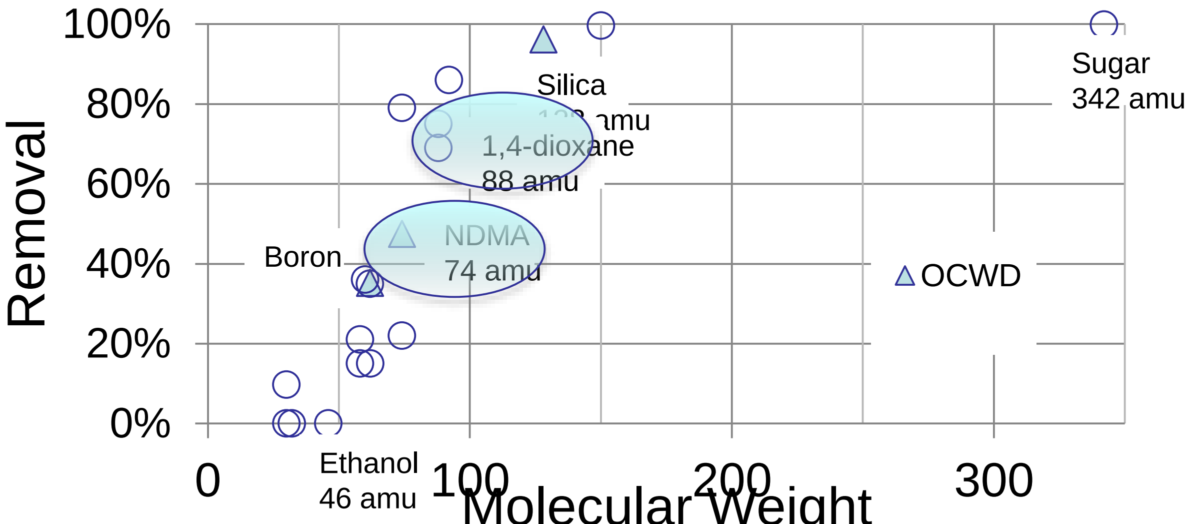


But RO is far and away the most important where chemical contaminants are concerned

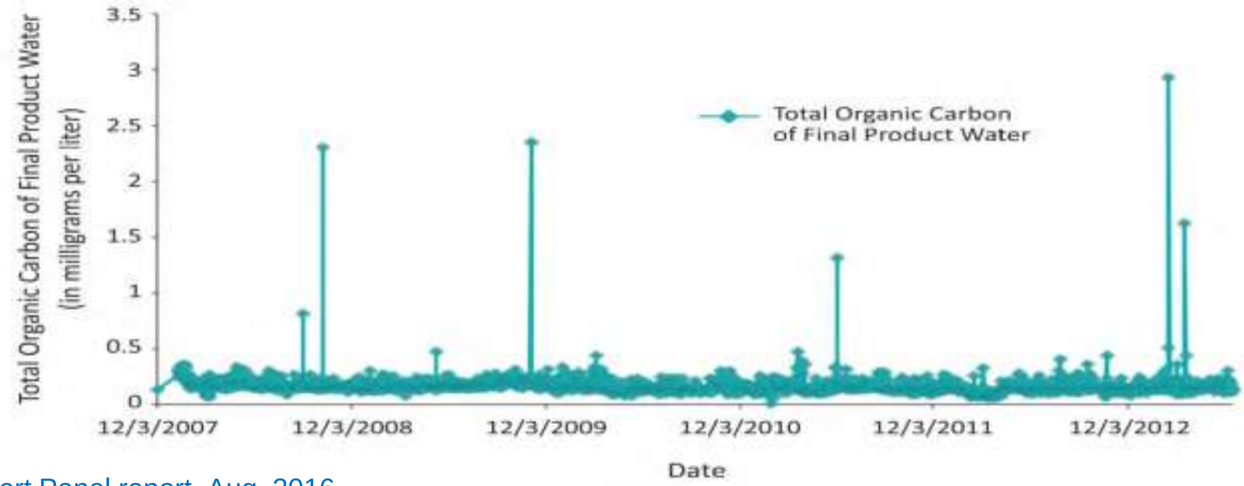
Preliminary results looking at rejection of uncharged compounds of various molecular weights



Preliminary results looking at rejection of uncharged compounds of various molecular weights



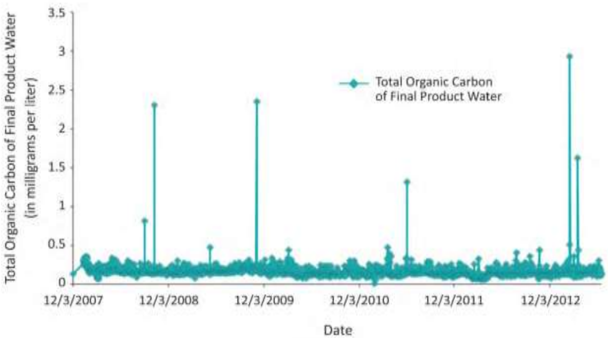
Five year record of TOC in FPW at GWRS[1]



Expert Panel report, Aug. 2016

SOP for TOC Spikes at GWRS

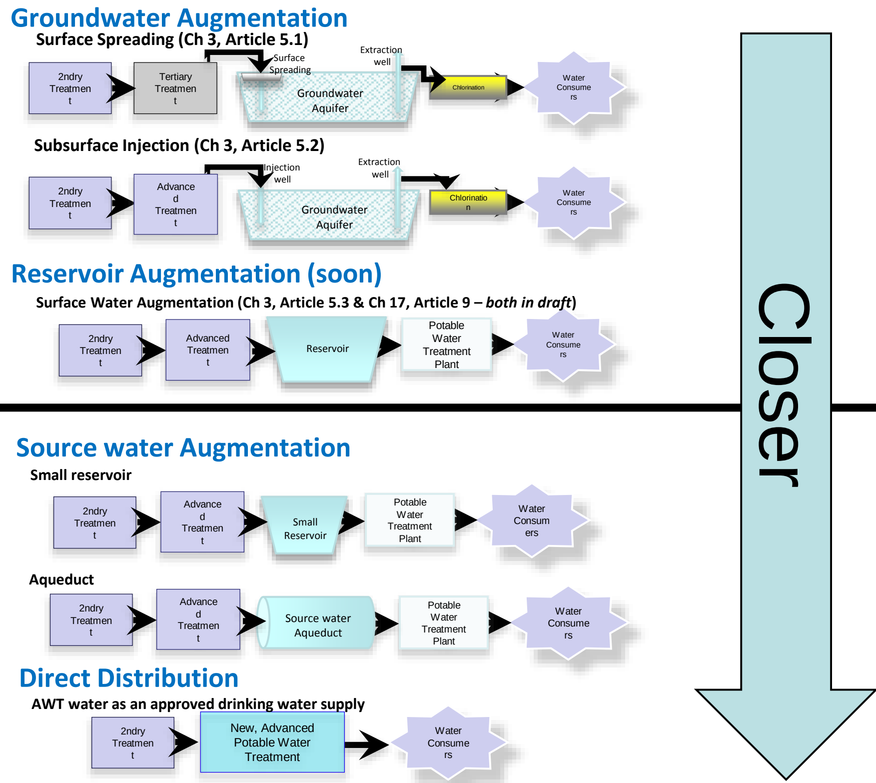
TOC Excursions



GWRS SOP for TOC Spikes

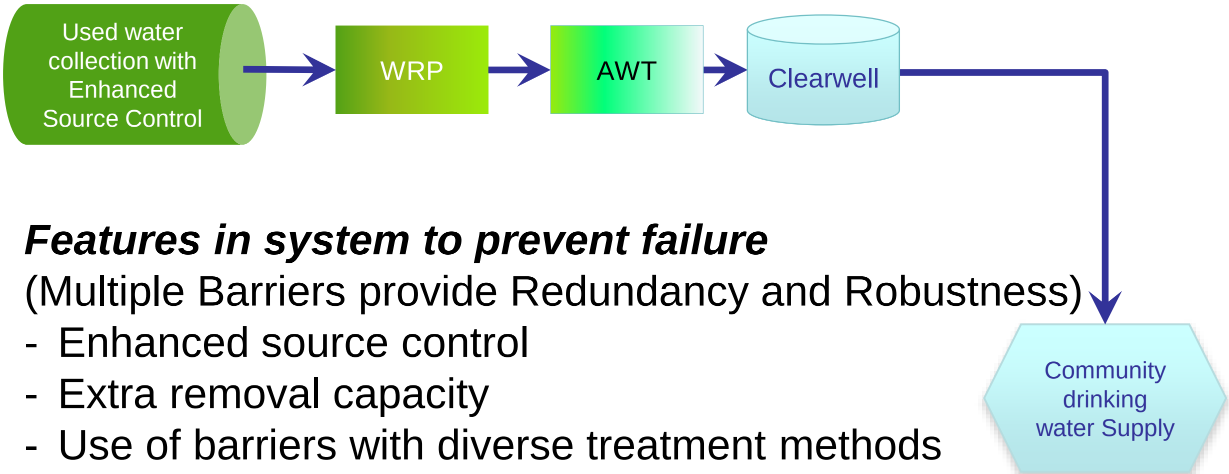
Regulated Forms of Potable In CA

Future Forms of Potable Reuse Being Discussed



Water Quality Assessment – Seen From a Bird's Eye

Direct Potable Reuse
[with extra reliability built in]



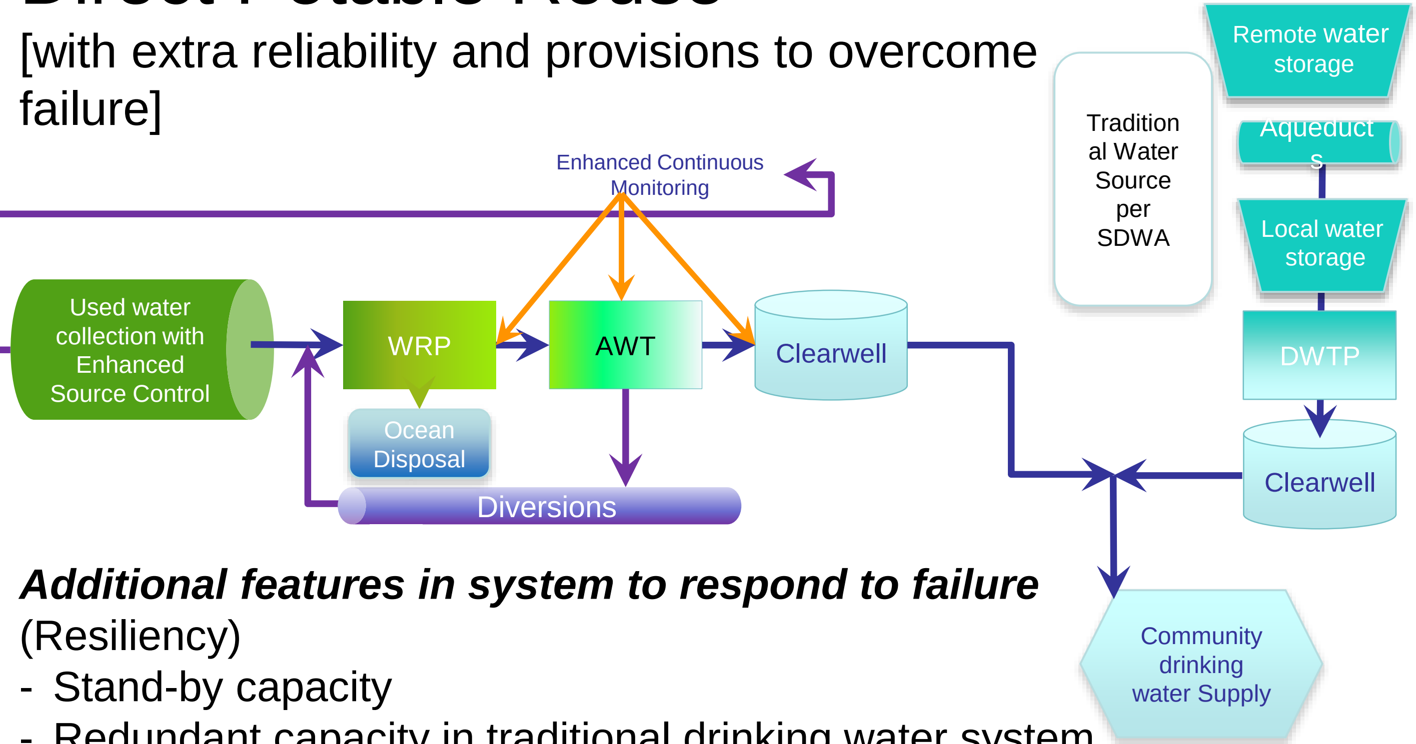
Features in system to prevent failure

(Multiple Barriers provide Redundancy and Robustness)

- Enhanced source control
- Extra removal capacity
- Use of barriers with diverse treatment methods
- Use of continuous monitoring at each critical control point

Direct Potable Reuse

[with extra reliability and provisions to overcome failure]



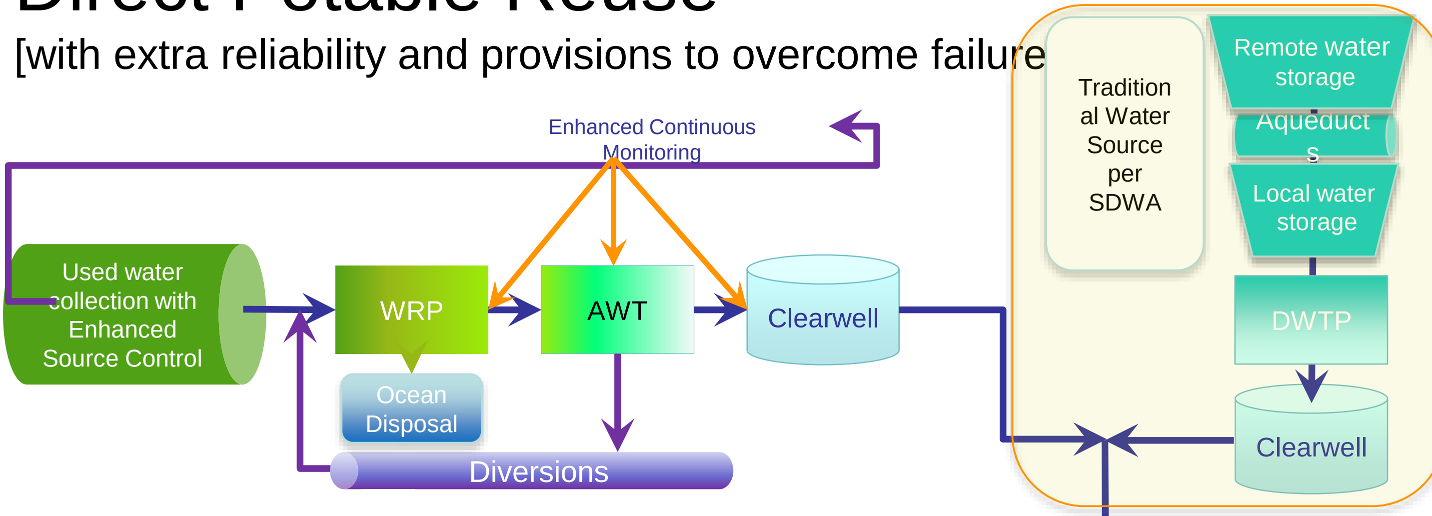
Additional features in system to respond to failure

(Resiliency)

- Stand-by capacity
- Redundant capacity in traditional drinking water system
- Redundant capacity in traditional wastewater disposal
- Enhanced monitoring to detect failure
- Ability to divert off-spec water

Direct Potable Reuse

[with extra reliability and provisions to overcome failure

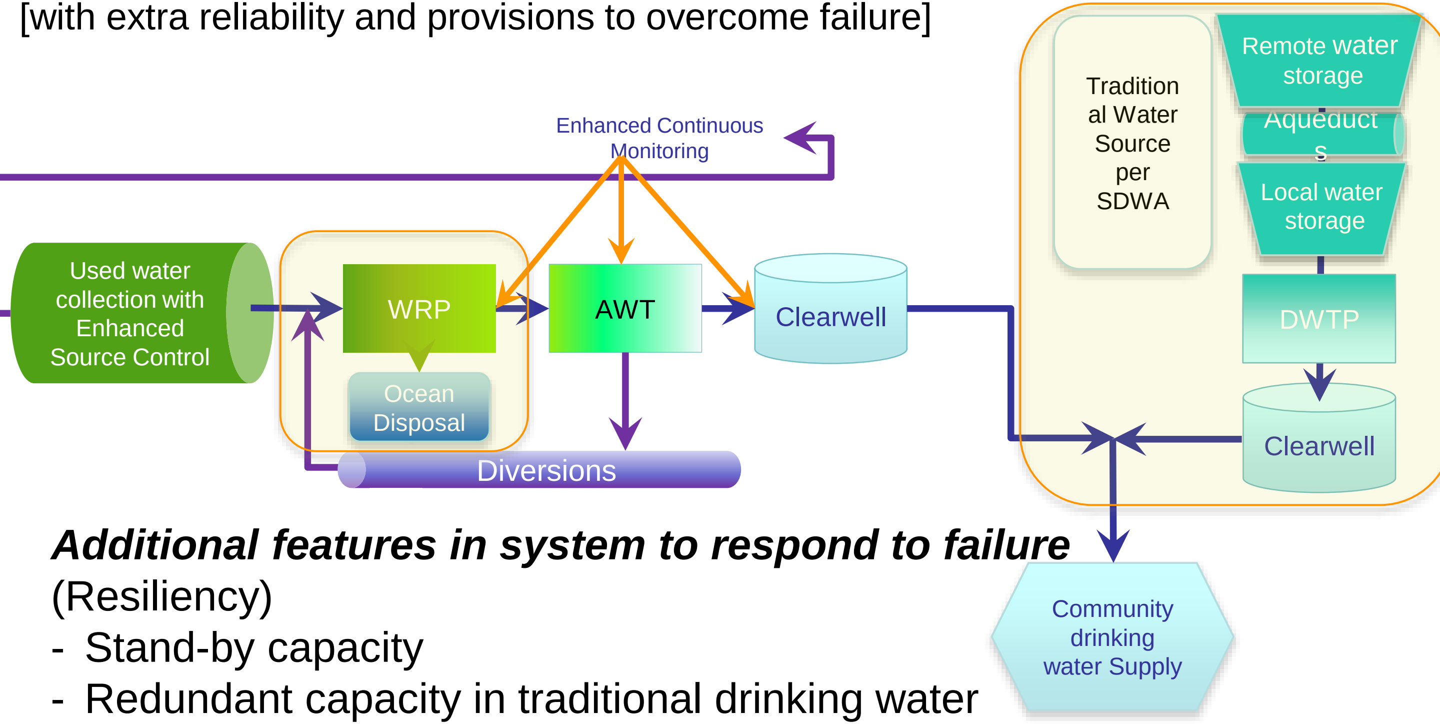


Additional features in system to respond to failure
(Resiliency)

- Stand-by capacity
- Redundant capacity in traditional drinking water system
- Redundant capacity in traditional wastewater disposal
- Enhanced monitoring to detect failure

Direct Potable Reuse

[with extra reliability and provisions to overcome failure]



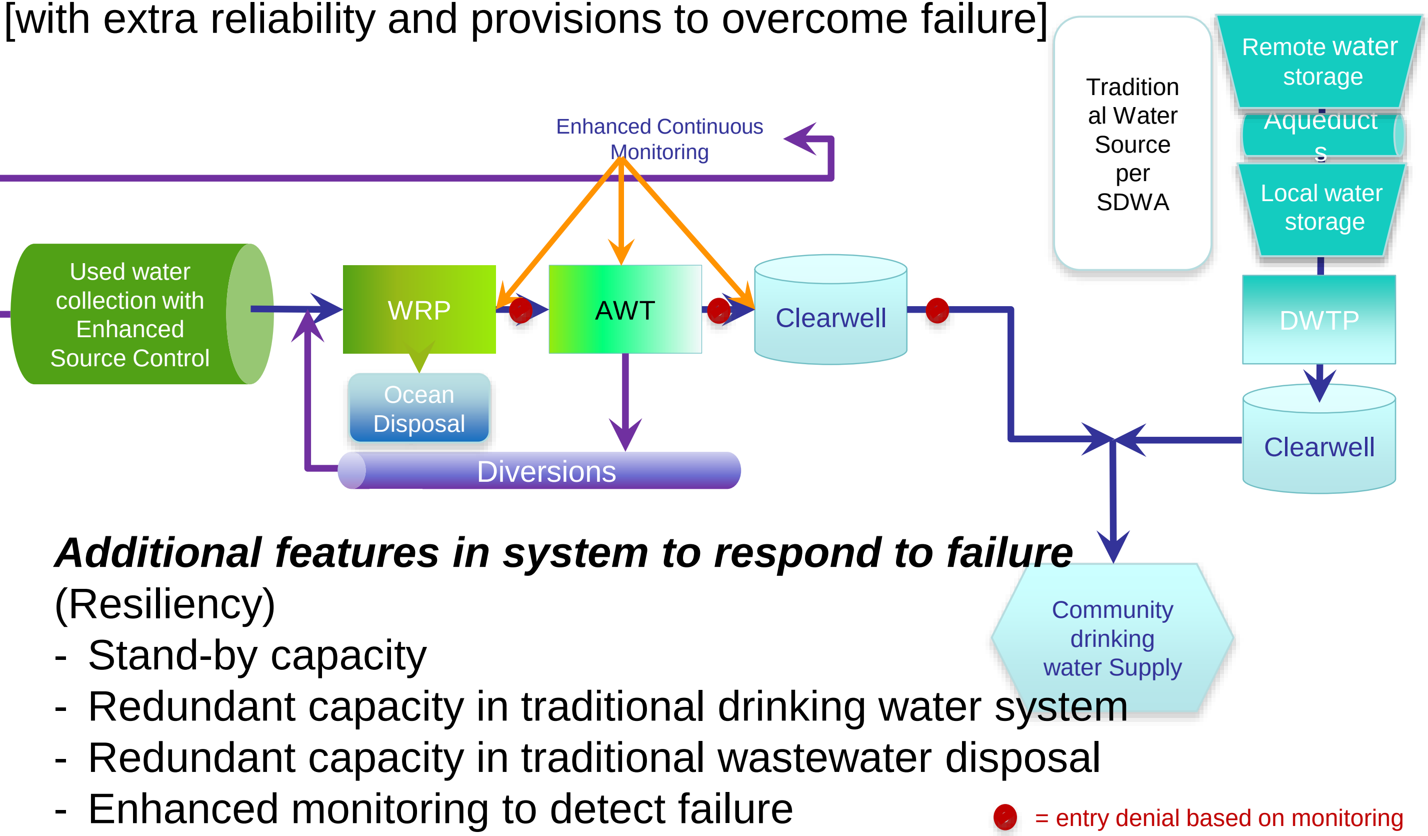
Additional features in system to respond to failure

(Resiliency)

- Stand-by capacity
- Redundant capacity in traditional drinking water system
- Redundant capacity in traditional wastewater disposal
- Enhanced monitoring to detect failure
- Ability to divert off-spec water

Direct Potable Reuse

[with extra reliability and provisions to overcome failure]



Additional features in system to respond to failure
(Resiliency)

- Stand-by capacity
- Redundant capacity in traditional drinking water system
- Redundant capacity in traditional wastewater disposal
- Enhanced monitoring to detect failure
- Ability to divert off-spec water

In Summary…
we can do it with today's tools

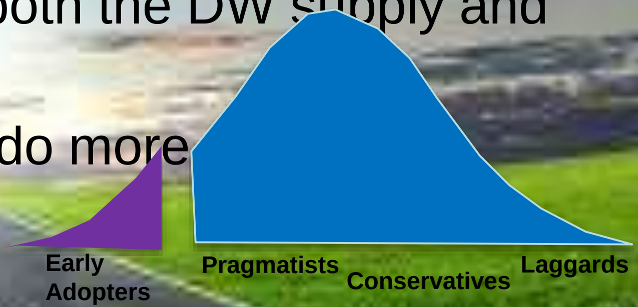
- We have goals that are protective
  - Pathogen risk below $^{10-4}$ infection/person/year
  - Chemicals below drinking water levels
- We have a candidate process train
- We have experience
- What we need:
  - Experience operating all these pieces together
  - Operators trained for this new challenge

What about the future?

- We'll be able to build more efficient systems in the future … today:
  - We have extra LRVs to assure reliability …
  - We remove all the chemicals to ND
  - We need redundancy in both the DW supply and WW disposal

What about the future?

- We'll be able to build more efficient systems in the future … today:
  - We have extra LRVs to assure reliability …
  - We remove all the chemicals to ND
  - We need redundancy in both the DW supply and WW disposal
- Early adoptors will need to do more



What about the future?

- We'll be able to build more efficient systems in the future … today:
  - We have extra LRVs to assure re
  - We remove all the chemicals to N
  - We need redundancy in both the
- Early adoptors will need to do n
- It seems likely we will move forward one step at a time