Water Circularity in CEA Facilities: Reduce, Remediate, Reuse

September 28, 2023

RESOURCE INNOVATION INSTITUTE

SOUTHERN CALIFORNIA EDISON

An EDISON INTERNATIONAL Company

SECTION 01

INTRODUCTION

POLL ALERT!

What kind of facility are you cultivating in?

- Small indoor building
- Warehouse
- Standard, vented greenhouse
- Semi-Sealed, air-conditioned greenhouse
- Container farms or pods
- N/A

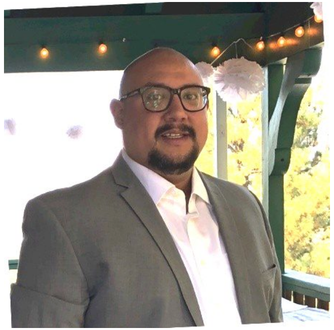
Agenda

Welcome, Introductions and Context	1:30 - 1:40
Economic Rationale and Water Conservation Practices	1:41 - 1:53
Water Disinfection and Purification Practices	1:54 - 2:16
Getting to Zero Liquid Discharge: Evaporators and Vacuum Distillation	2:17- 2:39
Water Storage and Biological Remediation	2:40-2:45
ICF Incentives for Energy Savings	2:45 - 2:53
Q&A	2:53- 3:00

Today's Experts

Rob Eddy

Jeff Martens



Carlos Salazar

Caleb Hayhoe

Access Your California Virtual Classroom

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Continue Learning Online

Free guidance on efficient cultivation

- Recordings of live workshops
- Tip clips
- Downloadable resources

Create an account at resourceinnovation.org/California

Product Type

ON DEMAND

California Efficient Yields: Lighting Best Practices for Efficient Controlled Environment Agriculture

Faculty: Kenda Branch | Rob Eddy | Casey Rivero
Duration: 1.5 hours
Format: Audio and Video
Original Program Date: Oct 18, 2022
Price: $0.00 - Non-Members Rate

More info » | Save for Later | Register

Product Type

ON DEMAND

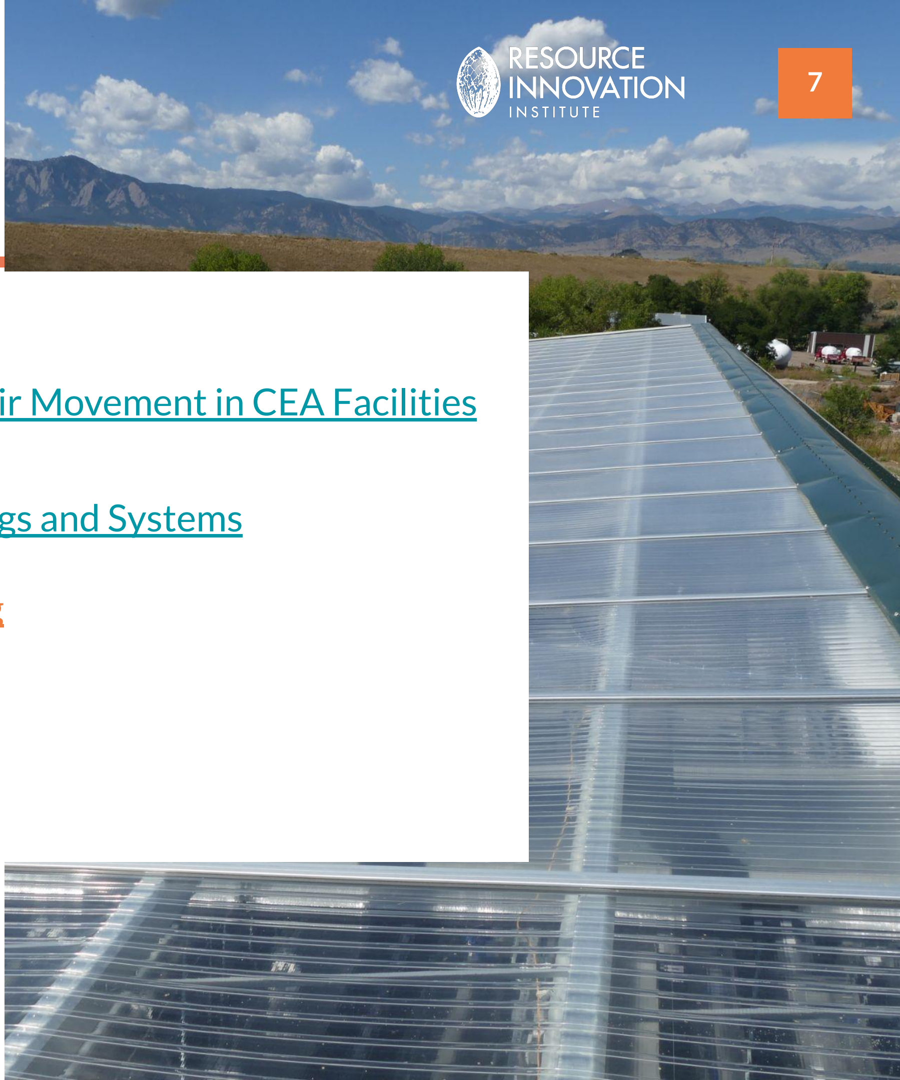
California Efficient Yields: Facility Design & Construction Best Practices for Efficient Greenhouses and Vertical Farms

Faculty: Brian Anderson | Rob Eddy | Holden Orler | Luis Trujillo
Duration: 2 hours
Format: Audio and Video
Original Program Date: Sep 20, 2022
Price: $0.00 - Non-Members Rate

More info » | Save for Later | Register

All live workshops are available for on-demand viewing!

Register for Upcoming Workshops



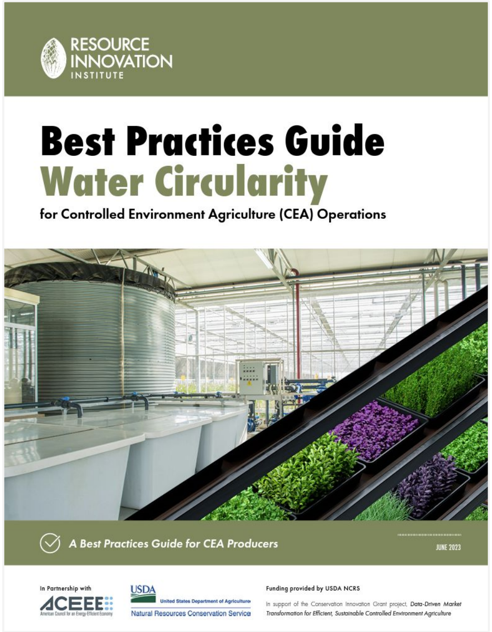
SCE funded Workshops:

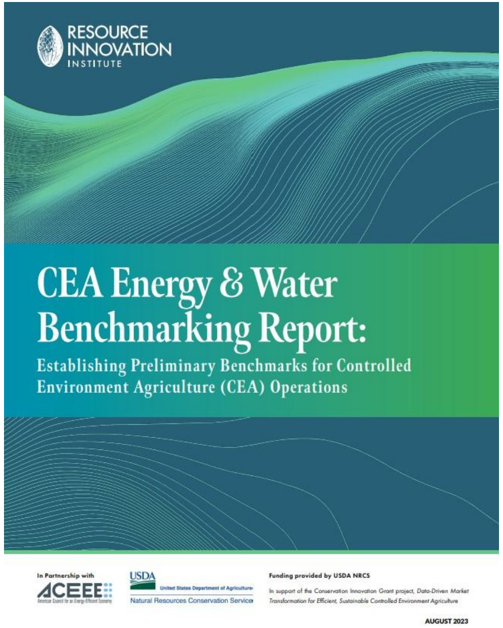
October 12 | The Critical Role of Building Envelopes and Air Movement in CEA Facilities

October 26 | Trust But Verify: Commissioning CEA Buildings and Systems

Register and access other free resources on the RII catalog

CEA Resources





Best Practices Guide Featuring contributions from 15 Working Group member companies

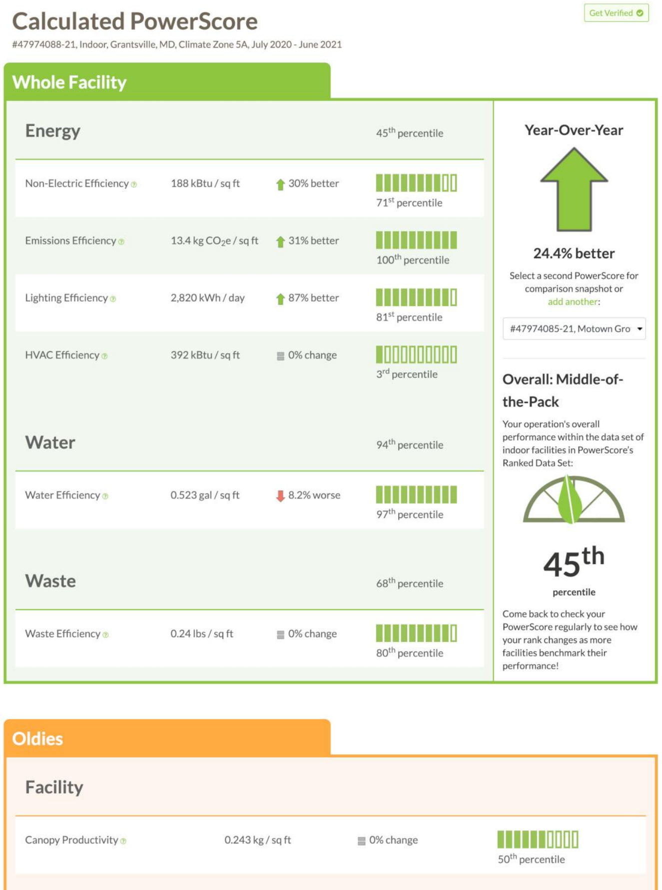
Benchmarking Report Featuring annual resource consumption and productivity of twelve producers growing a variety of crops in greenhouse and indoor facilities across the US.

Access the reports for free on the RII catalog

Start Collecting Data: Benchmarking

What data should you collect?

- Energy consumption (all fuel types)
- Water consumption
- Water quality
- Production
- Use controls & automation systems to improve data collection (improve understanding of subsystems)



POLL ALERT!
What kind of facility are you cultivating in?

Discuss Results

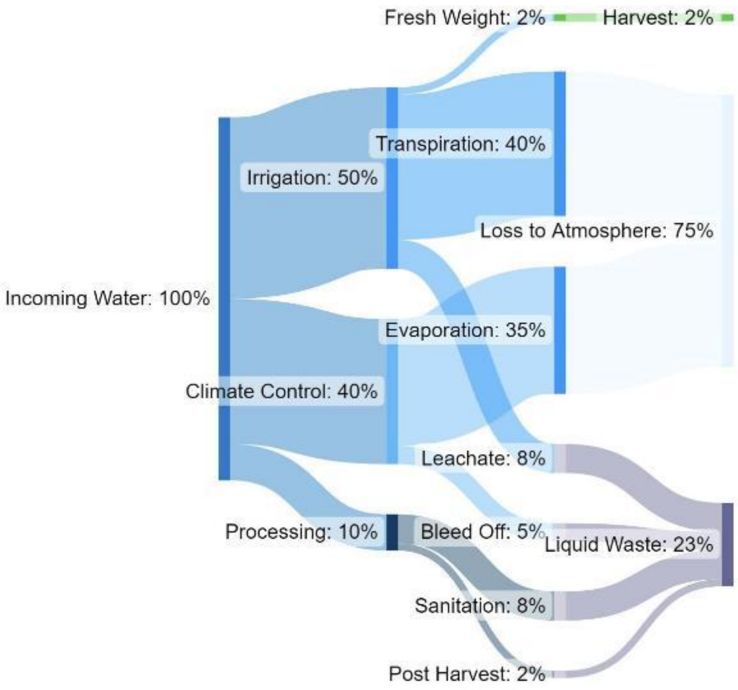
SECTION 02

Reducing Water Use in CEA Operations

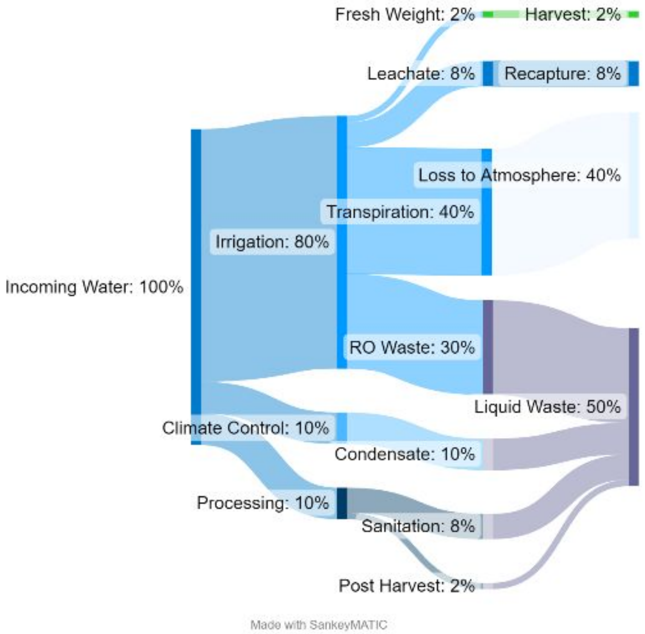
Knowledge Check!
About how much water that plants take up stays in the plant?

- 2%
- 28%
- 52%
- 98%

Fate of Water in CEA Operations



Standard Greenhouse



Standard Indoor Farm
(w/o condensate recapture)

Water Use Efficiency by Production Method

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Production Method	Country	Product water use (L/kg)	Product water use (gal/lb)
Open field, general	Israel, Spain, Turkey	100-300	12-36
Open field, drip irrigation	Israel	60	7
Greenhouse, unheated plastic	Spain	40	5
Glasshouse, unheated	Israel	30	4
Greenhouse, regulated ventilation, plastic	Spain	27	3
Glasshouse, advanced controls, CO_2	Netherlands	22	3
Glasshouse, advanced controls, CO_2, closed hydroponic system	Netherlands	15	2
Closed Greenhouse, advanced controls, CO_2, closed hydroponic system	Netherlands	4	0.5
Greenhouse, evaporative cooling	Mexico	Estimated: 100	Estimated: 12

Modified from Nederhoff, Elly & Stanghellini, Cecilia. (2010).

Economic Rationale For Reducing Water Consumption

Recirculating irrigation water has been shown to reduce water consumption by 20%-40%

Reducing irrigation water has been shown to reduce fertilizer costs by **40%-50%**

CEA producers report ROI in as little as two years due to fertilizer cost reduction

Source: Mohammed, N. (2019). The Advantages of a Closed Hydroponic System in Commercial Greenhouses [Slide show; Powerpoint]. Government of Alberta. https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/green14458/$FILE/Nabeel%20J%20M-%20Oct%202017.pdf

Sources of Water Waste in CEA Operations

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Priority Rank	Type of Water Waste	Relevant To All Facilities	Potential High Waste Volume	Release Causes Environmental Harm	Potential Crop Damage	Substitute for RO Water	Potential to Improve ROI on Treatment Costs	Difficult to Remediate
1	Over Irrigation and Leaks	X	X	X	X		X	
2	Irrigation Leachate	X	X	X			X	
3	Pesticide Drench/ Overspray	X		X				X
4	RO Reject Water		X					X
5	Evaporative Cooling Pad Bleed-Off		X					X
6	Condensate		X			X		
7	Washdown Water	X						X
8	Blowdown Water							X

Reducing Irrigation Waste in Hort Substrate Culture

Staal Plast

Netafim

Reducing Irrigation Waste by Smart Programming

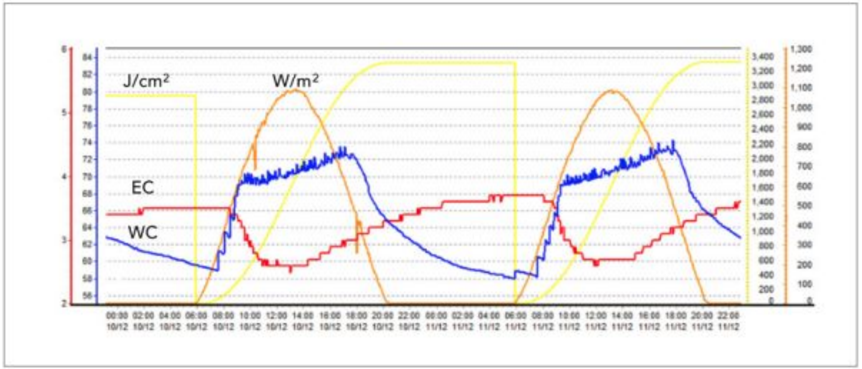
Example of layering environmental variables to trigger irrigation

Timeclock
Window of 2 hours after sunrise until 2 hours before sunset

Accumulated Light
Irrigates on light sum since previous irrigation

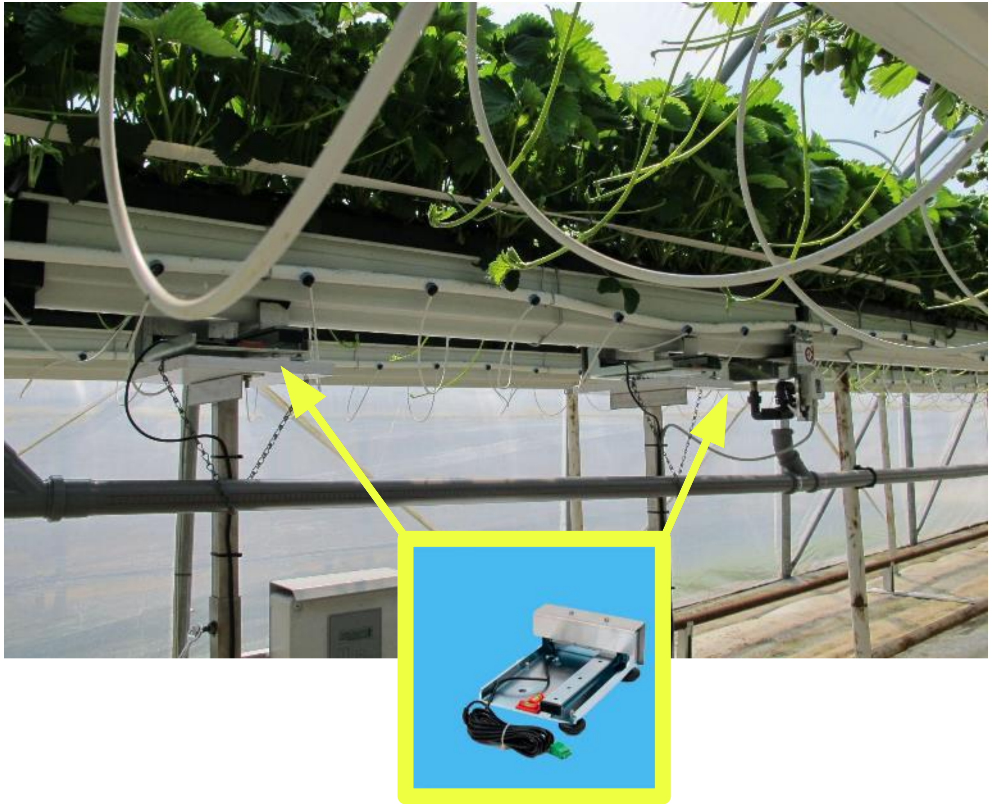
Maximum Interval
Maximum number of minutes since last irrigation (cloudy weather)

Crop Aging
Accum Light and Max Int adjusted by age



Priva and Grodan

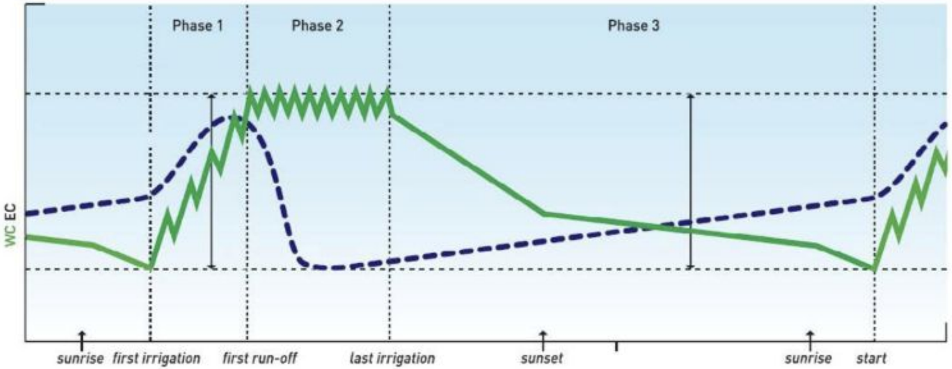
Reducing Irrigation Waste by Weight Scale Measurement



Powerplants Australia

Drain Sensors (volume, EC)

Reducing Irrigation Waste by Water Content Sensing



Sensor (WC and EC)

Priva and Grodan

Reducing Irrigation Waste by Using Recirculating Systems

Urban Ag News

Nutrient Film Technique

Raft Culture

Climapod.com

Aeroponics

Deep Water Culture

Plenty

Vertical NFT/Aeroponics

An Often Overlooked Source of GH Water Waste…

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Reducing Climate Control Water Waste

Knowledge Check!

About how much water that plants take up stays in the plant?

Discuss Results

SECTION 03

Water Quality in CEA Operations

POLL ALERT!

How do you measure water usage? Check all that apply:

- No metering
- One meter - incoming water
- More than one meter
- Tracked by irrigation controller
- Tracked by climate control computer

Topics

- Water Quality
- Reverse Osmosis
- Filtration
- Disinfection
- Design considerations

Water Quality RII Best Practice Guide

Characteristic	Desired Level
Soluble Salts (EC)	0.0-0.5 dS/m
pH	5.4-6.8
Alkalinity (Carbonate, $CaCO_3$) (Bicarbonate, HCO_3)	40-65 ppm 40-65 ppm
Hardness ($CaCO_3$ equivalent)	<100 ppm
Sodium (Na)	<50 ppm
Chloride (Cl)	<71 ppm
Sodium Adsorption Ratio	<4

Characteristic	Desired Level
Nitrogen {N} -Nitrate (NO_3) Ammonium (NH_4)	<5 ppm <5 ppm
Phosphorus (P)	<1 ppm
Potassium (K)	<10 ppm
Calcium (Ca)	<60 ppm
Sulfates (SO_4)	<30 ppm
Magnesium (Mg)	<5 ppm
Manganese (Mn)	<1 ppm

Characteristic	Desired Level
Iron (Fe)	<1 ppm
Boron (B)	<0.3 ppm
Copper (Cu)	<0.1 ppm
Zinc (Zn)	<0.2 ppm
Aluminum (Al)	<2 ppm
Chloride (Cl)	<2 ppm
Fluoride (F)	<1 ppm

WaterQual at www.cleanwater3.org/wqi.asp.

Table 1. Desirable characteristics of high-quality irrigation water.[6]

Water Quality - Results from well in Central Coast, CA

Ions	Well	Guidelines	Units
pH	**7.4**	5.4-6.8	-
Alkalinity "M"as $CaCO_3$	**206**	40-65	ppm
Fluoride as F	0.2	<1	ppm
Nitrate as NO_3	**8.1**	<5	ppm
Sulfate as SO_4	**385**	<30	ppm
Chloride as Cl	36.8	<71	ppm
Specific Conductance at 25°C	**1210**	760	µmhos
Aluminum Total as Al	<0.01	<2	ppm
Calcium Total as Ca	**113**	<60	ppm
Iron Total as Fe	<0.01	<1	ppm
Hardness Total as $CaCO_3$	**505**	<100	ppm
Potassium as K	3	<10	ppm
Magnesium Total as Mg	**53.9**	<5	ppm
Manganese Total as Mn	<0.005	<1	ppm
Sodium as Na	**60.2**	<50	ppm
Phosphorus total as P	<0.05	<1	ppm
Silica Total as SiO_2	38.2		ppm
Zinc Total as Zn	<0.005	<0.2	ppm

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pH	**7.4**	5.4-6.8	-
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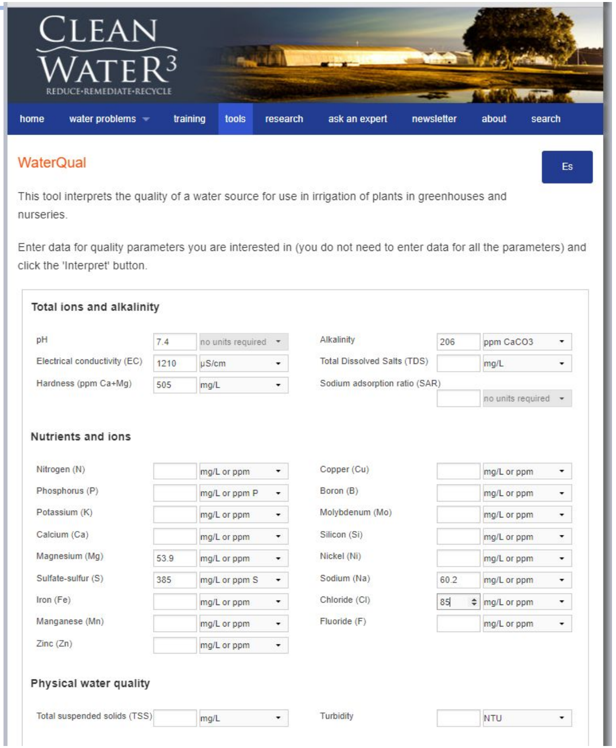

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Measurement	Test value	Result	Explanation of result
pH	7.4	High (>7)	*Interpreting the pH and alkalinity results together* pH and alkalinity levels this high means some pH adjustment (addition of acid) will be required in the spray tank with certain agrichemicals - check the pesticide label. Acidification is needed for hydroponic growers to lower pH to 6. For irrigation of containerized plants, injection of acid is recommended to reduce alkalinity and avoid an increase in substrate-pH over time. You may also need to include ammonium or urea nitrogen at 40% or above of total N in fertilizer to help avoid a rise in pH when using hydroponics or a container substrate.
Alkalinity	206 ppm $CaCO_3$	High (>150.01ppm $CaCO_3$)	
Electrical conductivity (EC)	1210 µS/cm	Moderate (>760 µS/cm)	A moderate to high level of dissolved ions. Likely to lead to salt accumulation in the substrate or recirculating solution, resulting in hard stunted growth and root damage. During mist propagation or overhead watering, may lead to salt burn on foliage. Manage with reverse osmosis, blending with a more pure water source such as rain water, leaching during irrigation, or periodic replacement of recirculating solution. Further water testing is needed to determine which ions are present, including fertilizer nutrients, alkalinity, chloride, or sodium.
Hardness (ppm Ca+Mg)	505 mg/L	High (>300.1 mg/L)	Ca and Mg levels this high are likely to produce residues on plant leaves, reduce efficacy and solubility of agrichemicals, clog irrigation equipment, and cause scaling and buildup on greenhouse boilers. Treatments such as reverse osmosis and acid injection are recommended.

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Water Quality - Results from Los Angeles, CA Municipality

Ions	Well	LA Muni	Guidelines	Units
pH	7.4	8	5.4-6.8	-
Alkalinity "M"as $CaCO_3$	206	120	40-65	ppm
Fluoride as F	0.2	1.3	<1	ppm
Nitrate as NO_3	8.1	<10.0	<5	ppm
Sulfate as SO_4	385	218	<30	ppm
Chloride as Cl	36.8	85.2	<71	ppm
Specific Conductance at 25°C	1210	1040	760	µmhos
Aluminum Total as Al	<0.01	0.18	<2	ppm
Calcium Total as Ca	113	65.8	<60	ppm
Iron Total as Fe	<0.01	<0.01	<1	ppm
Hardness Total as $CaCO_3$	505	273	<100	ppm
Potassium as K	3	4.5	<10	ppm
Magnesium Total as Mg	53.9	26.1	<5	ppm
Manganese Total as Mn	<0.005	<0.005	<1	ppm
Sodium as Na	60.2	93.4	<50	ppm
Phosphorus total as P	<0.05	<0.05	<1	ppm
Silica Total as SiO_2	38.2	7.15		ppm
Zinc Total as Zn	<0.005	0.106	<0.2	ppm

Table 7. Comparison of water attributes of high pH, alkalinity and hardness.

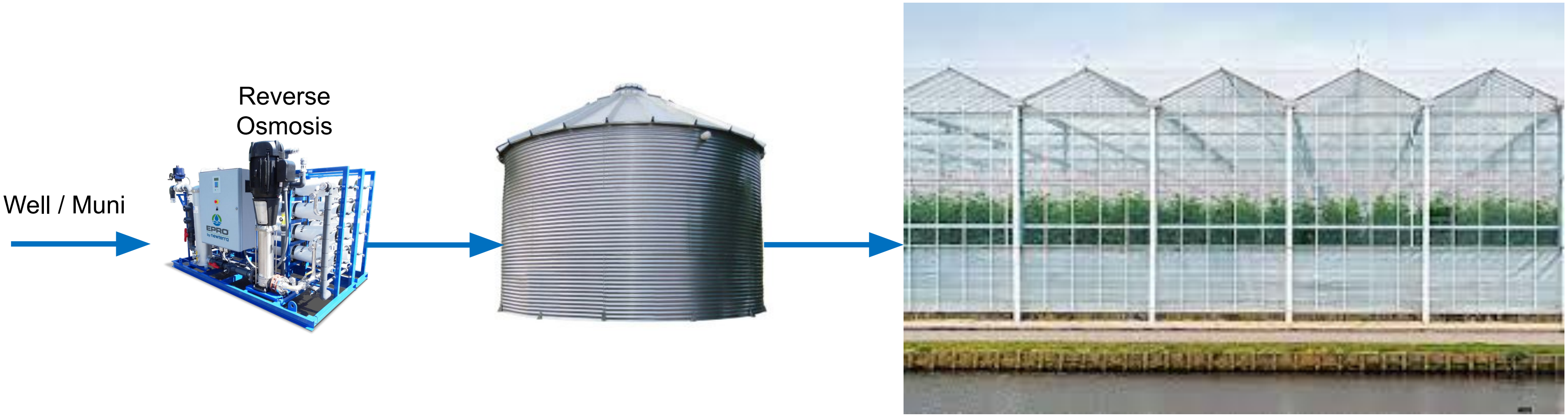
	High pH	Alkalinity	Hardness
Definition	Solutions with a pH value >7. A basic solution, as opposed to acidic.	Ability of the water to resist pH changes that occur due to acids. "Buffering capacity."	Amount of Ca and Mg in the water
Cause	Higher concentrations of OH^- ions than H^+ ions	Carbonates from limestone or dolomite bedrock	Calcium and magnesium from limestone or dolomite bedrock
Units of Measure	Expressed in logarithmic pH units	mEq/L, mg/L or ppm (meaning mg/L or ppm of calcium carbonate or bicarbonate equivalents)	mg/l or ppm
Impact on CEA operations	Minimal impact in container substrates if alkalinity and hardness are within acceptable range, but in hydroponics directly affects micronutrient solubility. Also affects activity of many agrichemicals	Increases pH of root substrate over time as carbonates accumulate, resulting in nutrient deficiencies	Scale deposits on plants and irrigation equipment. Clogged nozzles lead to plant stress.
Treatment	No treatment necessary if hardness and alkalinity within acceptable range for substrate production. High pH is adjusted with acid in hydroponic production.	Use of acidic fertilizer or acid injection into irrigation water. Reverse osmosis, deionization	Softening with KCl salts (not NaCl), reverse osmosis, deionization

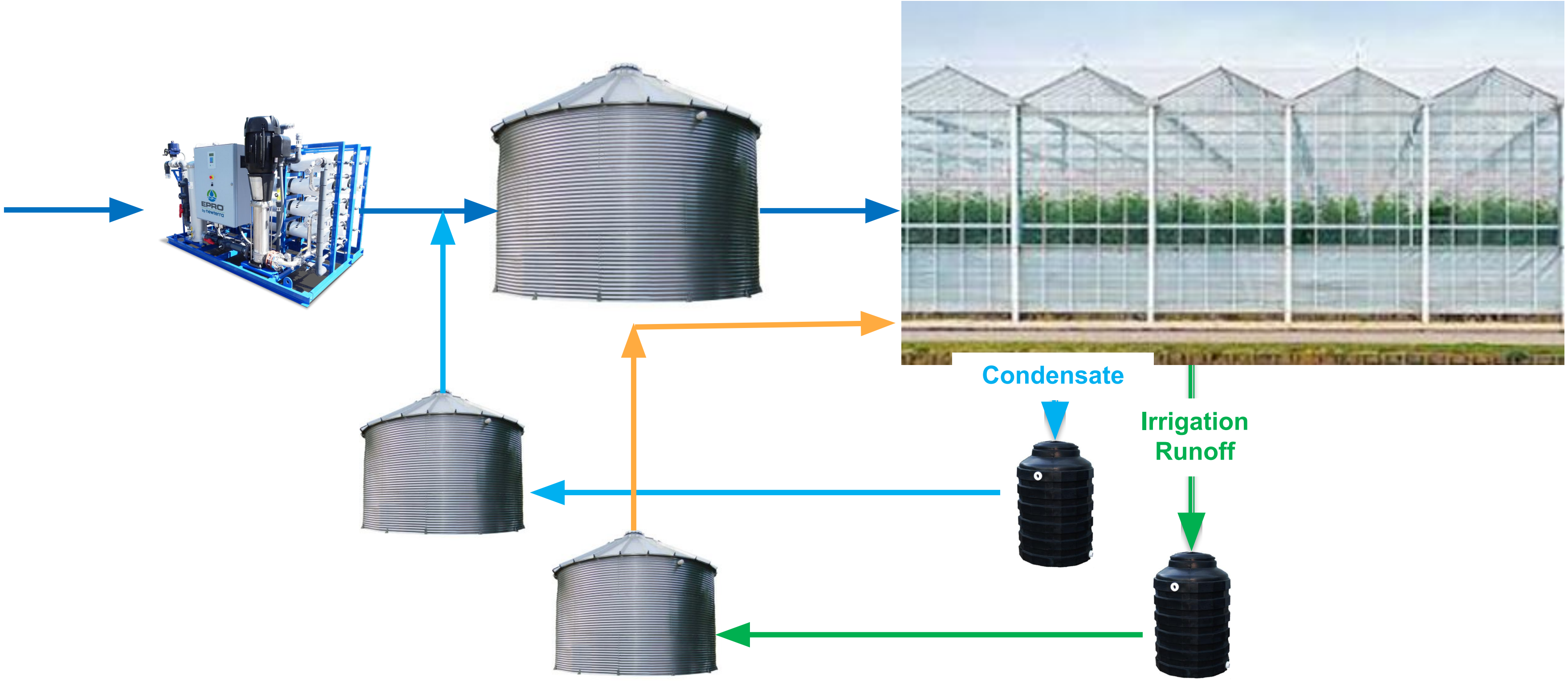
Water Quality - Results from Irrigation Runoff

Ions	Well	LA Muni	Irrigation	Guidelines	Units
pH	**7.4**	**8**	5.2	5.4-6.8	-
Alkalinity "M"as $CaCO_3$	**206**	**120**	4.7	40-65	ppm
Fluoride as F	0.2	**1.3**	0.1	<1	ppm
Nitrate as NO_3	**8.1**	**<10.0**	**665**	<5	ppm
Sulfate as SO_4	**385**	**218**	**120**	<30	ppm
Chloride as Cl	36.8	**85.2**	**<0.5**	<71	ppm
Specific Conductance at 25°C	**1210**	**1040**	**1970**	760	µmhos
Aluminum Total as Al	<0.01	0.18	<0.01	<2	ppm
Calcium Total as Ca	**113**	**65.8**	**119**	<60	ppm
Iron Total as Fe	<0.01	<0.01	**1.63**	<1	ppm
Hardness Total as $CaCO_3$	**505**	**273**	**418**	<100	ppm
Potassium as K	3	4.5	**268**	<10	ppm
Magnesium Total as Mg	**53.9**	**26.1**	**29.6**	<5	ppm
Manganese Total as Mn	<0.005	<0.005	**0.222**	<1	ppm
Sodium as Na	**60.2**	**93.4**	9	<50	ppm
Phosphorus total as P	<0.05	<0.05	**33**	<1	ppm
Silica Total as SiO_2	38.2	7.15	0.53		ppm
Zinc Total as Zn	<0.005	0.106	0.291	<0.2	ppm

Water Quality - Results from Condensate

Ions	Well	LA Muni	Irrigation	Condensate	Guidelines	Units
pH	**7.4**	**8**	5.2	6.5	5.4-6.8	-
Alkalinity "M"as $CaCO_3$	**206**	**120**	4.7	27.3	40-65	ppm
Fluoride as F	0.2	**1.3**	0.1	0.3	<1	ppm
Nitrate as NO_3	**8.1**	**<10.0**	**665**	3.8	<5	ppm
Sulfate as SO_4	**385**	**218**	**120**	7.9	<30	ppm
Chloride as Cl	36.8	**85.2**	**<0.5**	22.7	<71	ppm
Specific Conductance at 25°C	**1210**	**1040**	**1970**	147	760	µmhos
Aluminum Total as Al	<0.01	0.18	<0.01	0.13	<2	ppm
Calcium Total as Ca	**113**	**65.8**	**119**	13.5	<60	ppm
Iron Total as Fe	<0.01	<0.01	**1.63**	0.02	<1	ppm
Hardness Total as $CaCO_3$	**505**	**273**	**418**	49	<100	ppm
Potassium as K	3	4.5	**268**	1.1	<10	ppm
Magnesium Total as Mg	**53.9**	**26.1**	**29.6**	3.65	<5	ppm
Manganese Total as Mn	<0.005	<0.005	**0.222**	<0.005	<1	ppm
Sodium as Na	**60.2**	**93.4**	9	9.3	<50	ppm
Phosphorus total as P	<0.05	<0.05	**33**	<0.05	<1	ppm
Silica Total as SiO_2	38.2	7.15	0.53	2.55		ppm
Zinc Total as Zn	<0.005	0.106	0.291	0.066	<0.2	ppm


Reverse
Osmosis
Well / Muni
EPRO


Condensate
Irrigation
Runoff

Filtration fundamentals

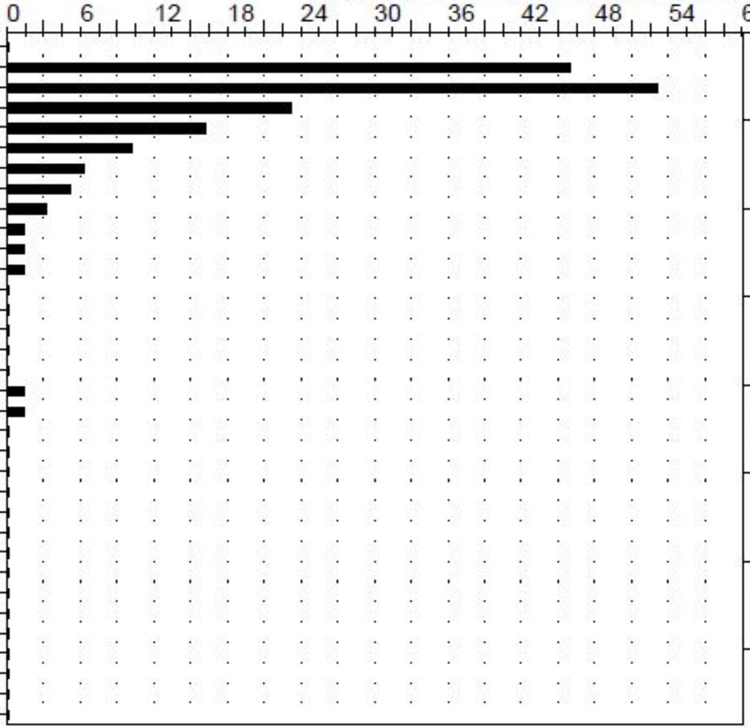
- Technologies
- Particle size analysis

Disinfection

- Dosage
- Mixing
- Location

Spectrex Laser Particle Counter 800-822-3940 v12.5

#	um	%	Interim Count
	<	0.00	0
1	1	26.25	46
2	2	30.45	53
3	3	13.21	23
4	4	9.28	16
5	5	5.99	10
6	6	3.70	6
7	7	2.83	5
8	8	2.01	3
9	9	1.10	1
10	10	1.10	1
11	11	0.91	1
12	12	0.46	0
13	13	0.32	0
14	14	0.23	0
15	15	0.27	0
16	16	0.00	0
17	17	0.62	1
18	22	0.58	1
19	27	0.27	0
20	32	0.04	0
21	37	0.09	0
22	42	0.04	0
23	47	0.13	0
24	52	0.00	0
25	57	0.04	0
26	62	0.04	0
27	67	0.00	0
28	72	0.00	0
29	77	0.00	0
30	82	0.00	0
31	87	0.00	0
32	92	0.00	0
	>	0.00	0



Filter 0%

A-T 0 s

S-T 48 s

Dilut'n 1001:1

Offset 0.00V

Gain 5.55x

Counts 176776

NSF Groups

Bin	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
	< 1	0.00	0.00%	0.00%	0.00%	0.0000
1	1-5	139,998.19	79.20%	13.77%	3.18%	0.8536
2	5-15	32,978.79	18.66%	33.96%	17.54%	4.7101
3	15-30	3,088.87	1.75%	23.81%	24.63%	6.6161
4	30-50	552.34	0.31%	17.98%	31.21%	8.3833
	50-100	157.81	0.09%	10.49%	23.43%	6.2936

Algae, plant material, soils, nutrients build up

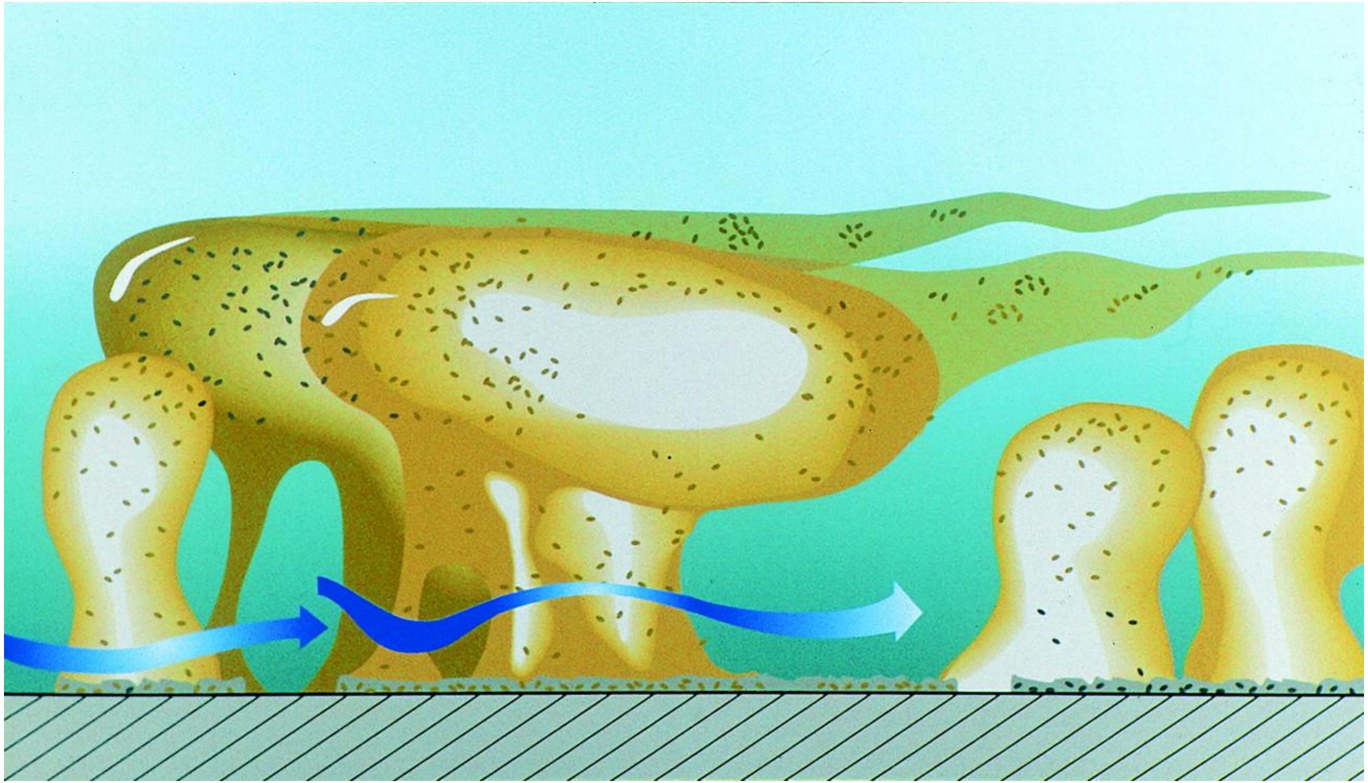
Bacteria and pathogens begin to grow in a protected environment

Outbreak occurs

Plant yield deteriorates

Fouling increases

Bacteria growth on a surface



Advantage of ozone

Strong oxidant

Doesn't build up residual

Increases O_2 levels

Oxidizer	ORP (Volts)
Ozone	2.08
Hydrogen Peroxide	2.02
Chlorine Dioxide	0.95

15 Minute Half Life (@ pH 7)
No stabilizer

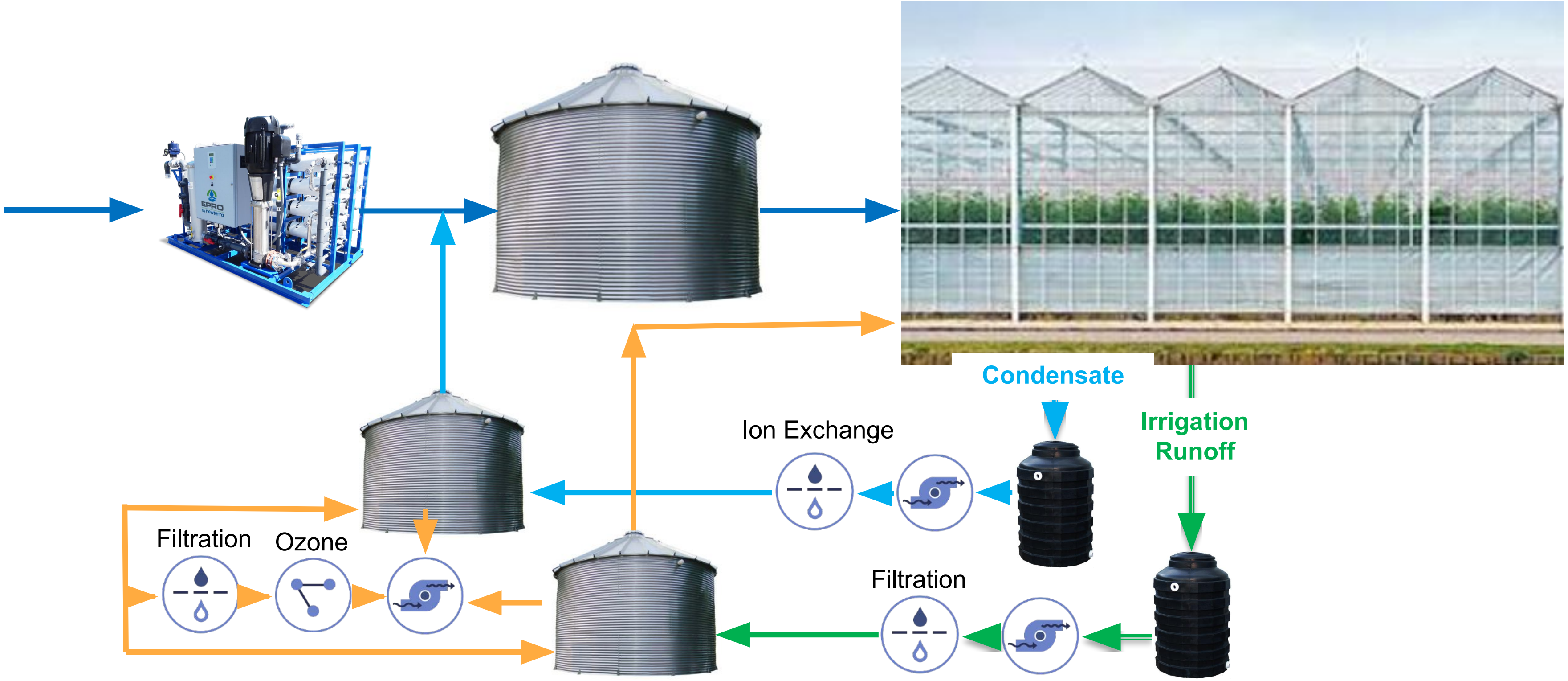
$O_3 + 2H^+ + 2e^- \leftrightarrow O_2 + H_2O$

Chemical Water Quality Treatment Systems

Technology	Notes	Pre Treatment Required	Treatment Range						Reaction Time	Residual Effect*	Reject Water Waste?	Footprint	Costs	
			Solids / organic material	Pathogens	Nutrients		Agri - chemicals	Controls Biofilm					Capital	Operating
					N	P								
Chlorine	Caution with chloramine formation when using in fertigation solutions	Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$ - $$	$
Chlorine Dioxide		Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$ - $$$	$$ - $$$
Peroxyacetic acid	(PAA) is a combination of acetic acid and hydrogen peroxide	Pre-filtration	✓	✓			Some	✓	Minutes	++		Small	$	$$ - $$$
ECA	Chlorine 2-10 ppm may damage lettuce	Softening	✓	✓				✓	Minutes	+		Small		
Ozone		Pre-filtration	✓	✓			Some	✓	Minutes	+		Medium	$$$	$
Copper Ionization		Pre-filtration		✓					Hours	++		Small	$$$	$
Peroxyacetic acid + UV	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	Minutes	++		Medium	$$$$	$$$ - $$$$
Peroxyacetic acid + Ozone	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	Minutes	++		Medium	$$$$	$$$ - $$$$
Ozone + UV	Synergistic Effect	Pre-filtration	✓	✓			Some	✓	Minutes	+		Medium	$$$$$	$$
Deionization	Higher purity than typically needed	Pre-filtration and Reverse Osmosis to reduce cost	✓	✓	✓	✓	✓		Minutes		+++	Medium	$$$$$	$$$

*All technologies other than point treatments such as membrane filtration or UV have potential for phytotoxicity at high doses. Make sure to follow label and manufacturer recommendations on dose, monitoring, and maintenance.

77 Modified from West, J., Huber, A., & Carlow, C. (2018). Water Treatment Guide for Greenhouses & Nurseries. Agriculture and Agri-Food Canada. and Fisher, P. (2020, February 18). Managing Water Quality and Biofilm for Indoor Production. Indoor Ag Science Cafe (episode 16). https://www.youtube.com/watch?v=O7wWVLIEdk


EPRO
Condensate
Irrigation Runoff
Ion Exchange
Filtration
Ozone
Filtration

POLL ALERT!

How do you measure water usage? Check all that apply:

Discuss Results

SECTION 04

Zero Liquid Discharge in CEA Operations

KNOWLEDGE CHECK!

Filtration can improve the efficiency of many other water treatments

- True
- False

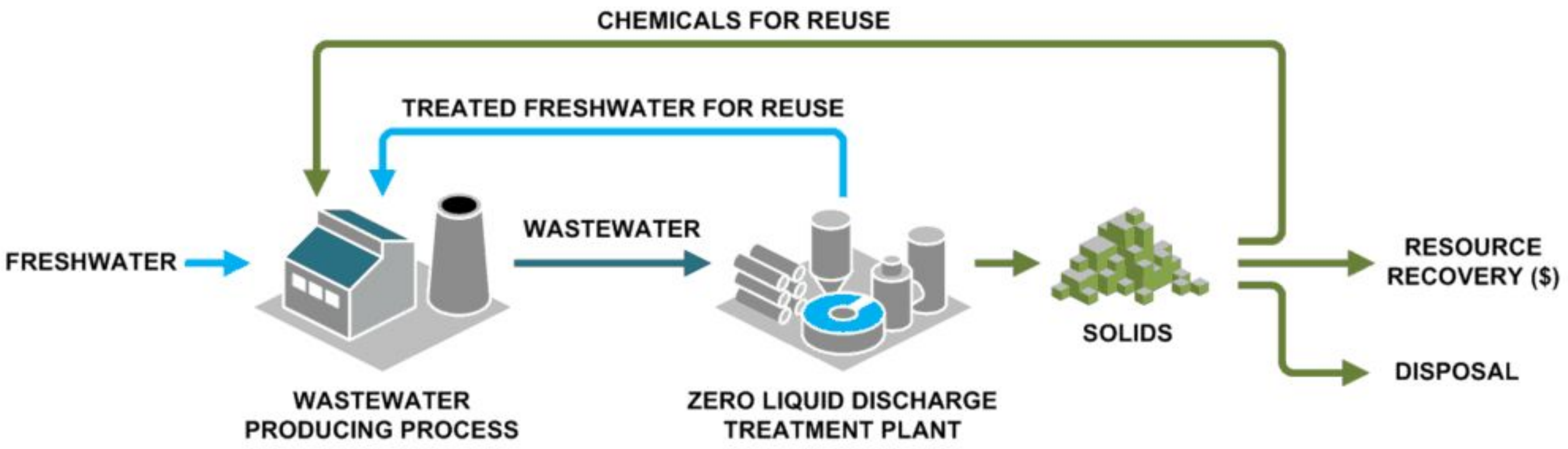
Zero Liquid Discharge (ZLD)

- What is it?
- History
- Why is it required/necessary
- How to achieve ZLD
- Pitfalls / Drawbacks

What is Zero Liquid Discharge (ZLD)?

What is Zero Liquid Discharge (ZLD)?

What is Zero Liquid Discharge (ZLD)?



History of ZLD

- Developed in USA for power plants
- Increased salinity of Colorado river in the 1970's created need for ZLD
- Major markets include USA, China, and India
- Growth in electronics, fertilizer, mining, and chemical industries

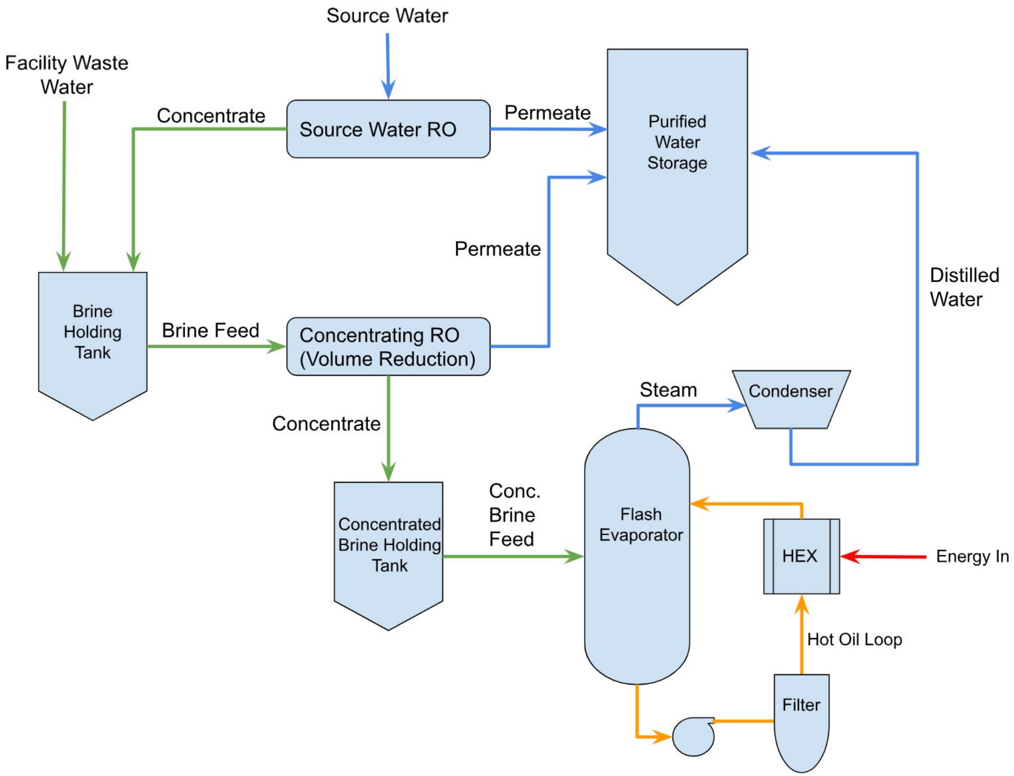
Why is ZLD required/necessary?

- Water Scarcity
- Environmental impact
- Growth of CEA
- Upcoming regulation
- Economic (in certain situations)
- Marketing

How to achieve ZLD?

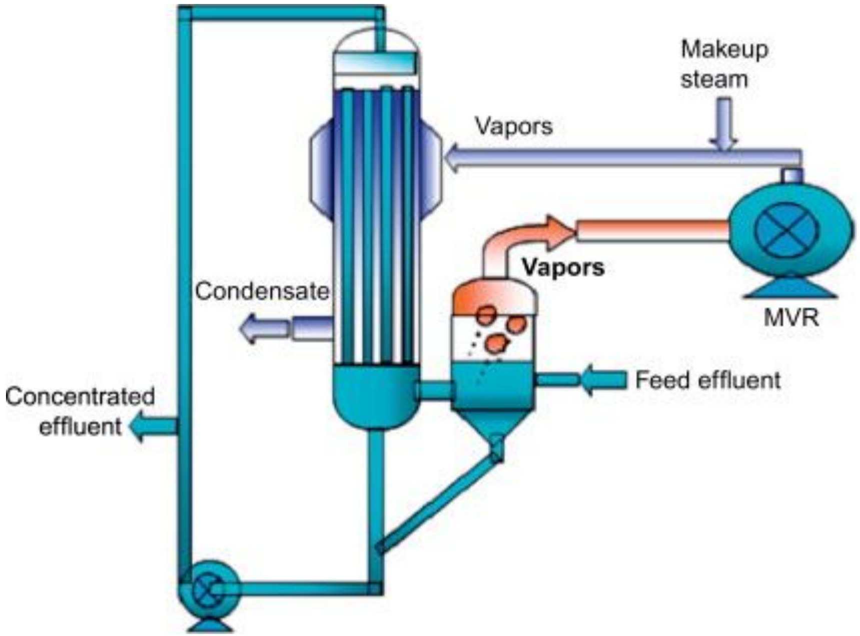
- New CEA facilities
- Existing CEA facilities
- Phased approach
- Technologies deployed

How to achieve ZLD? (Continued)



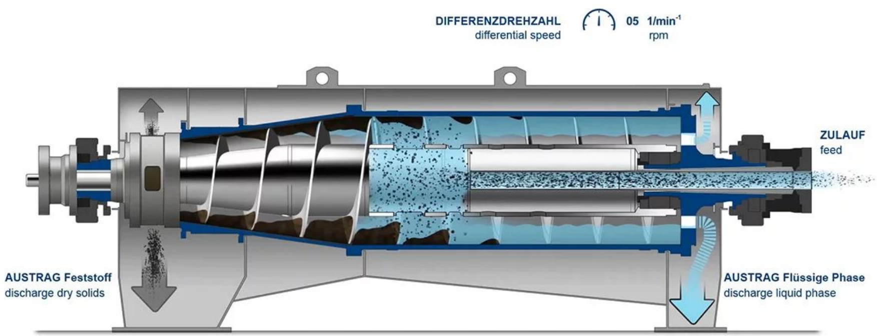
How to achieve ZLD? (Continued)

MVR Process

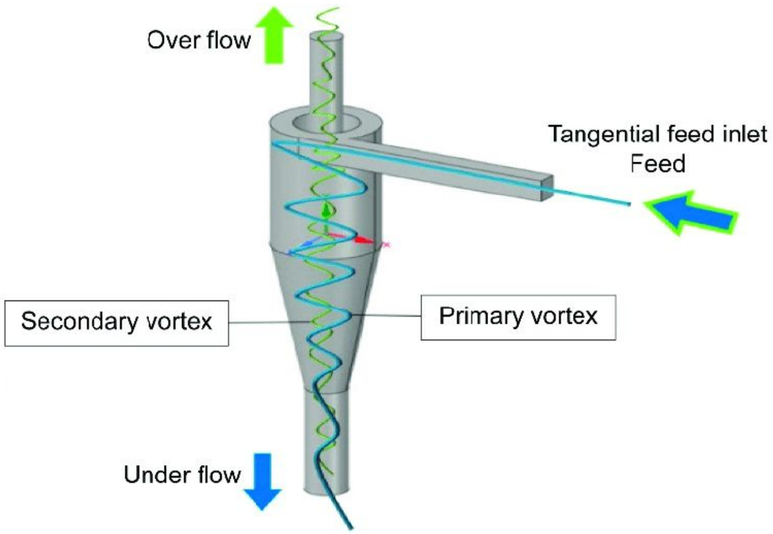


How to achieve ZLD? (Continued)

Solids Removal Final Stage



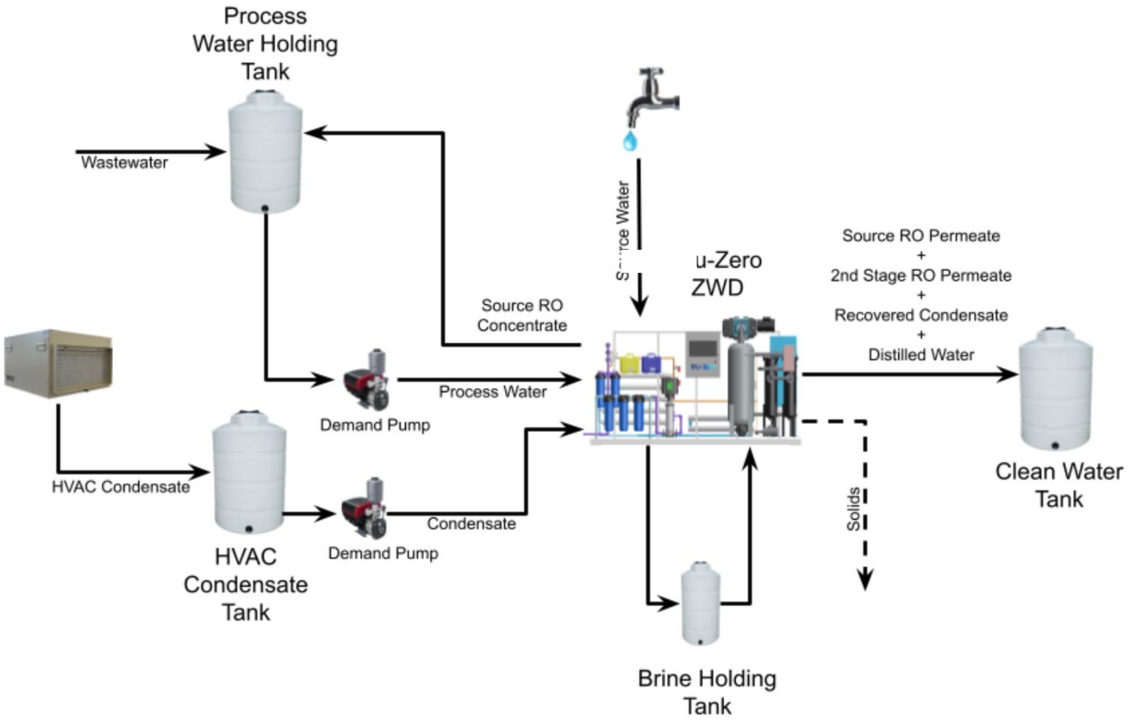
Decanter Centrifuge



Hydrocyclone

How to achieve ZLD? (Continued)

Process Flow Diagram of a ZLD system for CEA



Pitfalls / Drawbacks to ZLD

- Increased costs
- Design differences from other water treatment systems
- Complex streams of water
- Increased use of chemicals
- Energy consumption
- Solid waste disposal

KNOWLEDGE CHECK!

Filtration can improve the efficiency of many other water treatments

Discuss Results

SECTION 05

Water Storage and Bioremediation

RESOURCE INNOVATION INSTITUTE

POLL ALERT!

I have downloaded an RII Best Practices Guide in the last year

- YES
- NO
- NOT SURE

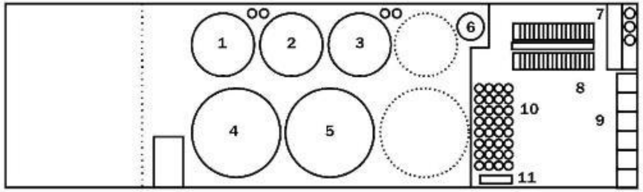
Storing Water for Reuse

Silver Bullet

Silver Bullet

Priva and Grodan

Silver Bullet



Priva and Grodan

Legend:

1+3	Dirty drain water basin
2	Clean drain water basin
4 + 5	Day water storage basins
6	Waste water basin
7	Liquid fertilizer stock tanks
8	Fertilizer dosing unit
9	A & B stock tanks (in this example 3 sets which will allow for different feed recipes)
10	Solid fertilizer storage area
11	Reverse osmosis unit

Biological Remediation Strategies

Biological Water Quality Treatment Systems														
Technology	Notes	Pre Treatment Required	Treatment Range						Reaction Time	Residual Effect	Reject Water Waste?	Footprint	Costs	
			Solids / organic material	Pathogens	Nutrients		Agri - chemicals	Controls Biofilm					Capital	Operating
					N	P								
Slow Sand Filters			✓	✓			*Possible*					Medium	$$	$
Constructed Wetlands			✓	Variable	✓	Variable	✓					Small - Large	$$-$$$	$
Floating Treatment Wetlands	Can be applied to existing stormwater ponds		✓	Variable	✓	Variable	✓					Small - Large	$-$$	$
Woodchip Bioreactors			✓	✓	✓	Some	*Likely*					Medium	$-$$	$
Hybrid Treatment Systems			✓	✓	✓	✓	*Likely*					Medium	$$-$$$	$

Biological Remediation Strategies - Constructed Wetlands

Bottom of wetland cells should be flat to permit even water drainage and flow for future wetland remediation efficiency.

Soils in dike and bottom of cells must have small particle size and compact readily to restrict water penetration.

White et al. (2011)

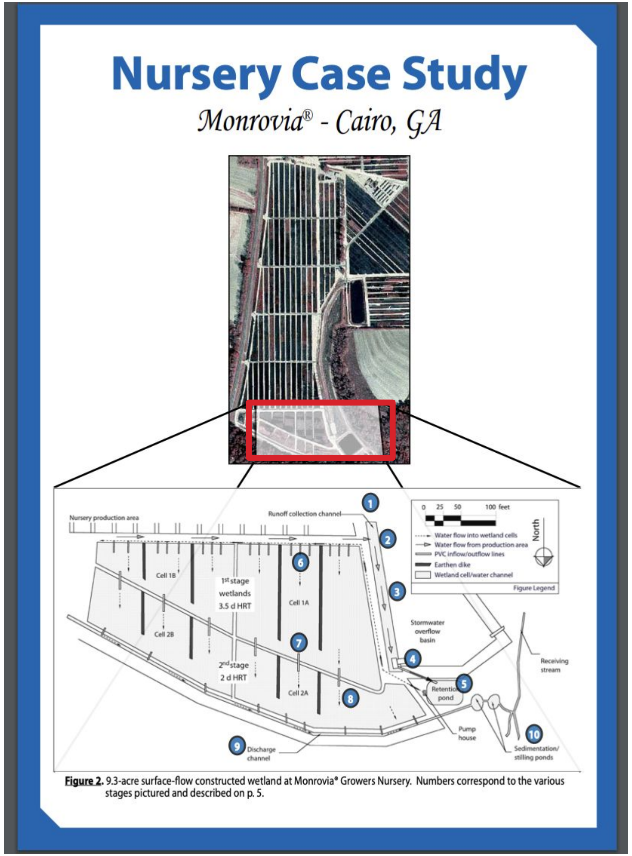
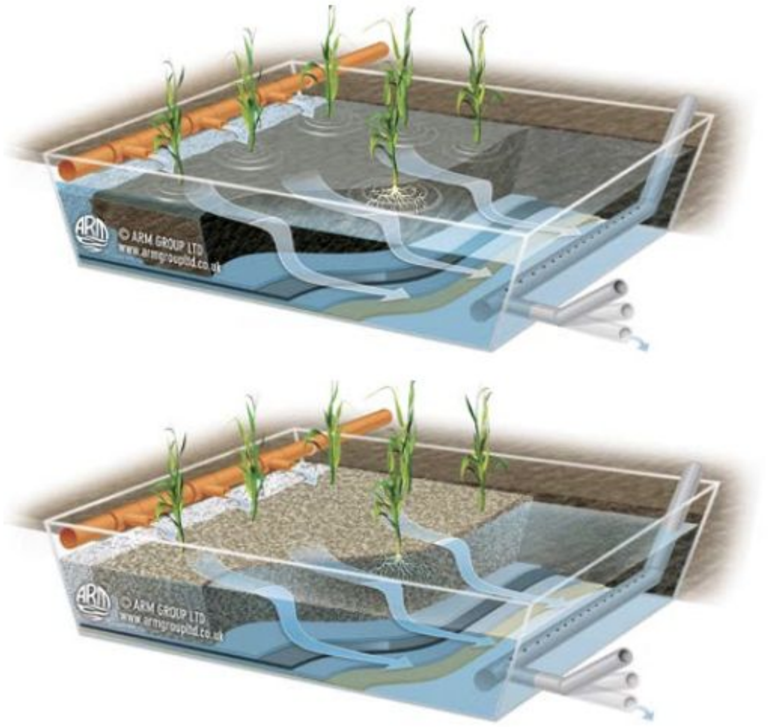


Figure 2. 9.3-acre surface-flow constructed wetland at Monrovia® Growers Nursery. Numbers correspond to the various stages pictured and described on p. 5.

Biological Remediation Strategies - Constructed Wetlands

Figure 28. Surface flow constructed wetland (top and Sub-surface flow constructed wetland.



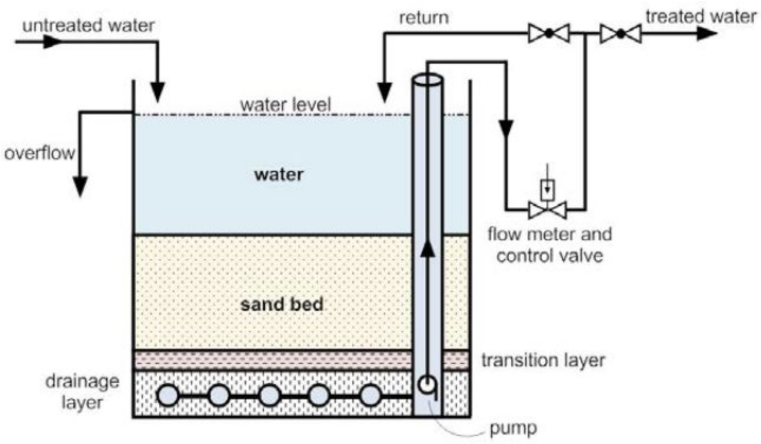
High removal efficiency:

- 50%-99% for nitrogen
- 25%-98% for phosphorus
- 84%-97% for pesticides (organochlorines, strobilurin/strobin, organophosphates, and pyrethroids)
- Heavy metals from plumbing and HVAC, copper (60%) and zinc (86%), along with lead, cadmium, aluminum, and manganese

Relative to the other water treatment technologies, these are *high removal rates* for these key agricultural pollutants.

Sources:
White et al. (2011).
Gill, L., Ring, P., Casey, B. M., Higgins, N. M., & Johnston, P. A. (2017).
Cheng, S., Grosse, W., Karrenbrock, F., & Thoennessen, M. (2002).

Biological Remediation Strategies - Slow Sand Filters



Oki, 2017

Netafim

Can be “containerized” for possible use in small spaces and even indoors

Biological Remediation Strategies - Floating Wetlands

Beeman. 2022 and Hurlev. 2022

Figure 29. Constructed wetland root system (left) and top growth.

In a study comparing removal rates of two leading brands' efficacy in treating agricultural wastewater, removal rates of 25%-40% for Total Nitrogen and 4%-48% for Total Phosphorus were achieved.

Can be retrofitted to existing holding ponds

Source: Fox, Owen and Sample, 2015

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I have downloaded an RII Best Practices Guide in the last year

Discuss Results

SECTION 06

Incentives Overview

Measure and Incentive Details Deemed

Measure	Measure Sizes	Incentive
Glycol Pump VFD	3hp – 25hp	$1,500 - $5,000 / unit
High-Low Bay LED Horticultural Lighting	4500 lumens – 65,900 lumens 130 LPW – 150+ LPW	$30 - $55 / unit
Efficient Ag Ventilation Fans	24 – 48 inch VSD	$200 / unit $195 / hp for VSD
Dust Collection Fan VSD	VFD on 10hp – 150hp motor	$2,000 - $15,000 / unit
VFD on Ag Well and Booster Pumps	<75 hp – 600hp	$75 - $200 / hp
Enhanced VFD on Ag Well and Booster Pumps	<75 hp – 600hp	$150 / hp

Measure and Incentive Details Custom + NMEC*

Measure	Measure Examples	Incentive per kWh	Incentive per kW
Lighting	• Lighting controls • Horticulture lighting • Exterior LED lighting • Interior high/low bay LED lighting	$0.15	$150
HVAC	• Horticulture HVAC system improvement • HVAC controls and VFDs • HVAC retro-commissioning • Chiller (HVAC) compressor – VFD • Ventilation fan – VFD • Efficient dehumidification system		
Refrigeration	• Refrigeration system insulation • Refrigeration system controls and VFDs • Condenser fan – VFD • Chiller (process) compressor – VFD • Evaporator coil fan – VFD • Efficient refrigeration condensing unit • Oversized air-cooled condenser • Efficient refrigeration compressors		

Measure and Incentive Details Custom + NMEC*

Measure	Measure Examples	Incentive per kWh	Incentive per kW
Irrigation	• Sprinkler/flood to drip irrigation • Distribution uniformity improvement • Irrigation scheduling	$0.15	$150
Compressed air	• Compressed air controls • Compressed air system optimization		
Pumping	• Pump controls and VFDs • Pumping system retro-commissioning • Agricultural pumping system upgrades • VFD on Ag well pump serving non-pressurized system (add-on equipment) • VFD on Ag pump serving non-pressurized system • Milk transfer pump – VFD • Vacuum pumps – VFD • Milking vacuum pumps - VFD		
Wastewater	• Wastewater system controls and VFDs • High efficiency blowers • High efficiency pumps • High efficiency aerators • Wastewater treatment management system • Wastewater chemically enhanced primary treatment/sedimentation		

Deemed & DI Water Heating Requirements & Incentives

Customers who located within a Disadvantaged Community (DAC) as defined by CalEnviroscreen 4.0 will receive a higher incentive than customers who are not. Customers who are classified as Hard-to-Reach (HTR) will be offered measures at no-cost.

Measure	Requirements	Standard Deemed Rebate	Increased Rebate for DAC Customers	DI Cost to Customer (for HTR and DAC customers only)
Steam Traps	• >= 12 hours of average daily use • Any pipe size	$150 each	$300 each	Not eligible
Storage Water Heaters	• 40 Gallon • >= 0.64 UEF • Input rating <= 75 kBtu/hr	$20 per rated MBtuh	$27 per rated MBtuh	No Cost
Storage Water Heaters	• 40 Gallon • >= 0.68 UEF • Input rating <= 75 kBtu/hr	$22 per rated MBtuh	$29 per rated MBtuh	No Cost
Process Boiler	• >=90% CE Hot Water • Must replace standard efficiency process boiler • Input rating <=20,000 kBtu/hr	$6 per rated MBtuh	$10 per rated MBtuh	Not eligible
Process Boiler	• >=85% CE Hot Water • Must replace standard efficiency process boiler • Input rating <=20,000 kBtu/hr	$2 per rated MBtuh	$2.95 per rated MBtuh	Not eligible
Process Boiler	• >= 83% CE Steam • Must replace standard efficiency process boiler • Input rating <=20,000 kBtu/hr	$3 per rated MBtuh	$4.35 per rated MBtuh	Not eligible

Data Source: California Energy Data and Reporting System Cost-Effectiveness Tool

Deemed & DI Insulation Requirements & Incentives

Customers who located within a Disadvantaged Community (DAC) as defined by CalEnviroscreen 4.0 will receive a higher incentive than customers who are not. Customers who are classified as Hard-to-Reach (HTR) will be offered measures at no-cost.

Measure	Requirements	Standard Deemed Rebate	Increased Rebate for DAC Customers	DI Cost to Customer (for HTR and DAC customers only)
Tank Insulation	• 1" temperature application 120-170 degrees F solution	$2.50/ square foot	$4.00/ square foot	No Cost
Tank Insulation	• 2" temperature application 170-200 degrees F solution	$3.25/ square foot	$6.00/ square foot	No Cost
Fitting Insulation (no steam for DI)	• 1" minimum insulation thickness • <= 1 inch pipe • <=15 and >15 PSIG Steam or Hot Water • ½" minimum pipe diameter	$10.00-$15.00/fitting	$15.00-$22.50/fitting	No Cost (Hot Water only)
Fitting Insulation (no steam for DI)	• 1" minimum insulation thickness • > 1 inch pipe • <=15 and >15 PSIG Steam or Hot Water	$14.00-$40.00/fitting	$22.00-$60.00/fitting	No Cost (Hot Water only)
Pipe Insulation (no steam for DI)	• One inch minimum insulation thickness • <= 1" inch pipe, <=15 and >15 PSIG Steam, Hot Water, Indoor, and Outdoor – ½" minimum pipe diameter • 1 inch – > 4 inch, <=15 and > 15 PSIG Steam, Hot Water, Indoor, and Outdoor	$2.50/ foot	$4.00/ foot	No Cost (Hot Water only)

Data Source: California Energy Data and Reporting System Cost-Effectiveness Tool

Deemed & DI Greenhouse Requirements & Incentives

Customers who located within a Disadvantaged Community (DAC) as defined by CalEnviroscreen 4.0 will receive a higher incentive than customers who are not. Customers who are classified as Hard-to-Reach (HTR) will be offered measures at no-cost.

Measure	Requirements	Standard Deemed Rebate	Increased Rebate for DAC Customers	DI Cost to Customer (for HTR and DAC customers only)
Greenhouse Heat Curtain – Existing or New Construction	• Natural gas savings rating >=40% • Single layer interior curtain • The heat curtain must have a warranty/product life of five years • The installation must allow the curtain to be automatically or manually moved into place.	$0.35/ square foot floor area	$0.50/ square foot floor area	No Cost
Greenhouse Infrared Film - Existing	• Must be infrared, anti-condensate, polyethylene plastic • Minimum thickness of six thousandths of an inch • Cannot be installed on greenhouse walls	$0.05/ square foot film area	$0.10 / square foot film area	No Cost
Greenhouse Infrared Film – New Construction	• Must be infrared, anti-condensate, polyethylene plastic • Minimum thickness of six thousandths of an inch • Cannot be installed on greenhouse walls	$0.02/ square foot film area	$0.02/ square foot film area	No Cost

Data Source: California Energy Data and Reporting System Cost-Effectiveness Tool

Custom Measure Incentives

Measures	Standard Incentive ($/Therm Savings)	DAC Incentive ($/Therm Savings)
Boiler System Upgrades	$2.50	$3.00
Condensing Unit Heater	$2.50	$3.00
Direct Contact Water Heater	$2.50	$3.00
Greenhouse Environmental Controls	$2.50	$3.00
Greenhouse IR Space Heating	$2.50	$3.00
Greenhouse Under-Bench Heating	$2.50	$3.00
Heat Recovery, Dehumidification Air Reheat	$2.50	$3.00
Process Heat Recovery	$2.50	$3.00
Process Pump VFD	$2.50	$3.00
Combined Heat and Power	$2.50	$3.00
Infrared Heating for Post-Harvest	$2.50	$3.00
Greenhouse Envelope Upgrades	$2.50	$3.00
Ozone Cleaning and Laundry	$2.50	$3.00
Greenhouse Retro commissioning	$1.25	$1.25

Measure and Incentive Eligibility

Basic Requirements for All Measures

- Customers must meet general program eligibility requirements to apply for AgEE Program incentives
- All equipment must be new electric powered equipment
- Qualifying equipment must be purchased and installed between July 5, 2022, and December 31, 2025. The purchase date of the equipment must be within the calendar year that the application is submitted unless indicated otherwise.
- All required efficiencies must exceed Title 20 and 24 standards.

Training and education on broader participation benefits

- Energy savings
- Non-energy benefits (e.g., increased yield, worker safety, animal comfort, etc.)

- Building energy assessments
- Energy benchmarking
- Technical support in selecting the most beneficial measures
- Ongoing guidance regarding measure installation and usage
- Financing assistance through incentives and promotion of on-bill financing
- Provide customers with education on accessing grants such as those from the USDA
- Dedicated outreach for DAC and HTR customers

Program Delivery and Customer Services

Get in touch with us:

Caleb Hayhoe
AgEE Program Manager
caleb.hayhoe@icf.com

Ben Cooper
AgEE Program Manager
benc@ensave.com

icf.com

linkedin.com/company/icf-international/

twitter.com/icf

https://www.facebook.com/ThisIsICF/

Panel Q & A

Today's Experts

Rob Eddy

Rob@resourceinnovation.org

Jeff Martens

jmartens@newterra.com

Carlos Salazar

carlos@bearag.com

Caleb Hayhoe

caleb.hayhoe@icf.com

CONTACT US

RESOURCE INNOVATION INSTITUTE

Visit us at
www.ResourceInnovation.org

P.O. Box 5981
Portland, Oregon 97228
rob@resourceinnovation.org
bryce@resourceinnovation.org