Texas Pacific Water Resources, LLC

BENEFICIAL REUSE UPDATE

TWS FREEZE DESALINATION

PBWIEC - 2025

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PROJECT PHASES

Phase 1 - Project Viability

- Proof of concept with Permian brine
- Soil & Water Quality investigation & research partnerships
- Patenting
- Input Requirements (power, water, land, etc)

Phase 2A - RRC Land Apply

- Operation under RRC Land Apply Pilot Permit
- TPDES application submittal
- Plans for scaling of equipment
- Commercial discussion

Phase 2B - 10K BPD Site

- Construction of 10K BPD Site
- Large scale power investigation
- 100 ac. restoration area
- Co-gen opportunities

PHASE 1: KEY FINDINGS

Phase 1 irrigated native plants and alfalfa in Reeves and Loving County soils with 500-1500TDS range of desalinated produced water.

Crops

Alfalfa does not discriminate.
Alfalfa grown with 1000 TDS water was the healthiest, BUT, excess salt & trace metals lead to unhealthy soil conditions in the 1500 TDS samples.

Ultimately we determined that utilizing treated PW for crop irrigation is safe, but will likely require supplemental nutrients until further research is done on nutrient availability in the concentrate.

Water Quality

Water quality was analyzed in reference to the RRC Land Application standards, & TCEQ Discharge standards.
When blending with RO Concentrate, water did not meet specs for various metals present in PW.
While iron, nitrogen, boron, calcium, magnesium and potassium were good for the plants, the other excess metals could be harmful long term.

Permitting

Permits were filed during phase 1 to continue our research outdoors with alfalfa, and to dicharge to waters of TX in Reeves County.
Water quality & treatment train design were dialed in to include the following:

- Pre-treatment
- Desal. <30,000TDS
- GAC+Zeolite+SW RO
- GAC+UV
- End use conditioning

PHASE 1 - RESULTS CONT.

CONTROL

- Chloride
  - Reeves - (-25.2 ppm)
  - Loving - (-34.9 ppm)
- Sodium Absorption Ratio
  - Reeves - (-0.22)
  - Loving - (-0.43)

500 ppm TDS

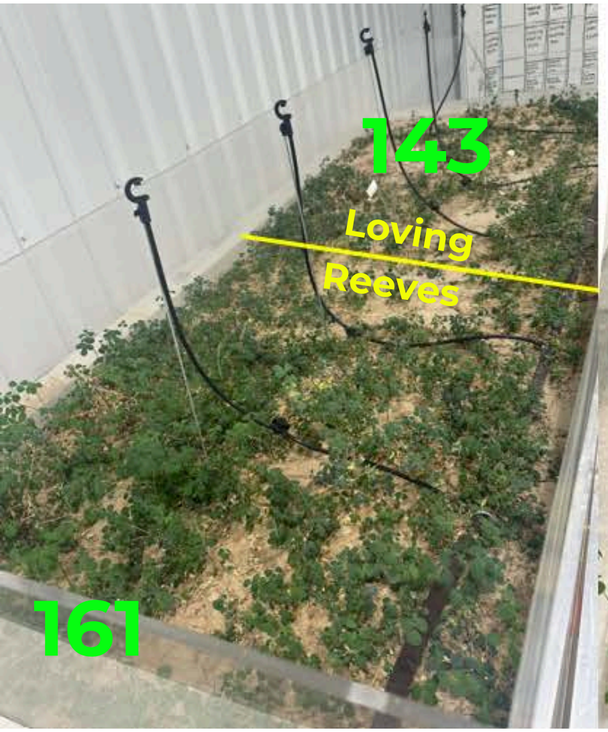
- Chloride
  - Reeves - (+26.3 ppm)
  - Loving - (+127.9 ppm)
- Sodium Absorption Ratio
  - Reeves - (+0.48)
  - Loving - (+0.04)

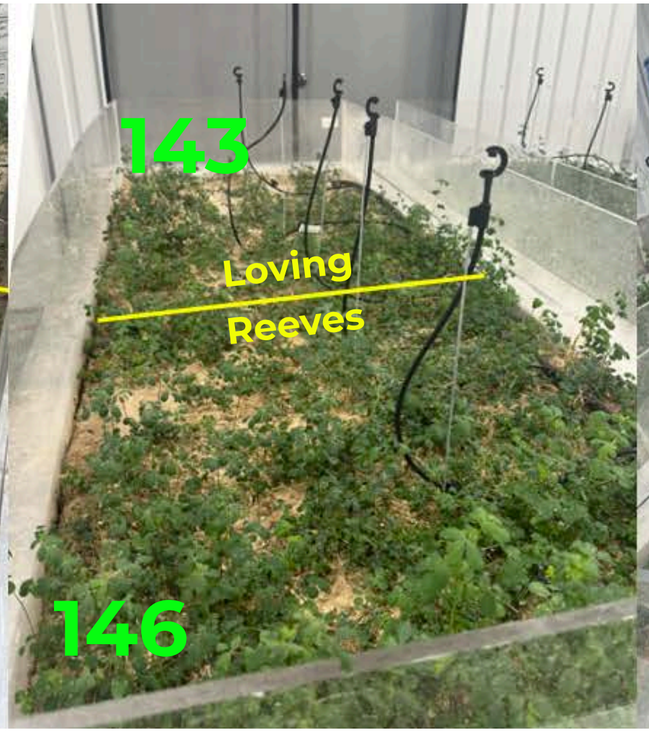
1000 ppm TDS

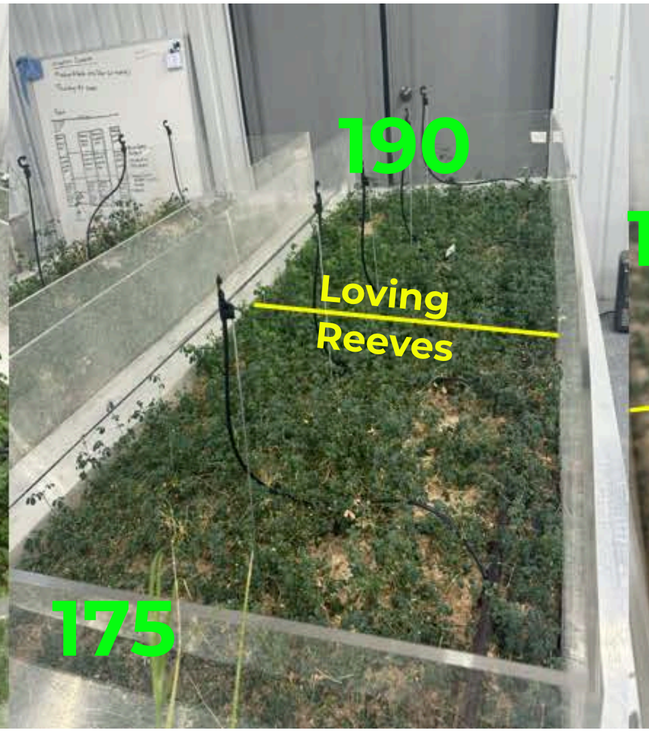
- Chloride
  - Reeves - (+118 ppm)
  - Loving - (+98.8 ppm)
- Sodium Absorption Ratio
  - Reeves - (+1.26)
  - Loving - (+1.04)

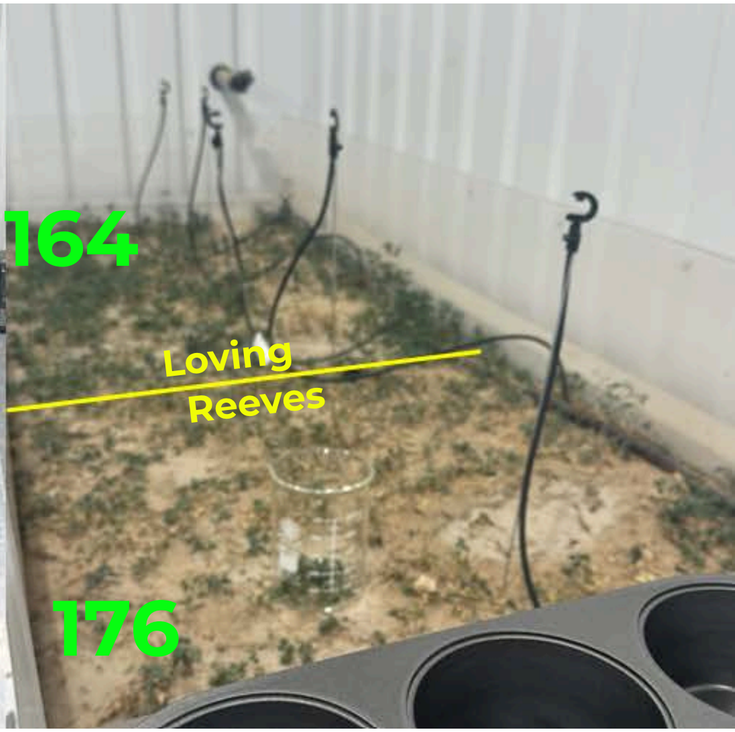
1500 ppm TDS

- Chloride
  - Reeves - (+297 ppm)
  - Loving - (+317 ppm)
- Sodium Absorption Ratio
  - Reeves - (+1.55)
  - Loving - (+1.93)









*photos taken at end of project.

PHASE 1 - RESULTS CONT.

EUROFINS MIDLAND	CLIENT: TEXAS PACIFIC WATER RESOURCES SUMMARY OF ANALYTICAL RESULTS FOR JOB#: 880-39374-1 METHOD: METALS BY EPA200.7 REV 4.4 PROJECT NAME:										
			02/13/2024	02/13/2024		02/13/2024		02/13/2024		02/13/2024	
ANALYTE NAME	UNITS	CAS#	Raw-PW	Oxidized	% dec.	Pre-Treatment	% dec.	Pre-RO-PW	% dec.	Post-RO	% dec.
Aluminum	mg/L	7429-90-5	<10.0	<10.0		<10.0		<10.0		<0.200	
Arsenic	mg/L	7440-38-2	<0.500	<0.500		<0.500		<0.500		<0.0100	
Barium	mg/L	7440-39-3	3.33	2.63	21%	2.49	25%	0	100%	<0.0100	
Cadmium	mg/L	7440-43-9	<0.250	<0.250		<0.250		<0.250		<0.00500	
Calcium	mg/L	7440-70-2	3840	3200	17%	3010	22%	580	85%	8.77	100%
Chromium	mg/L	7440-47-3	<0.500	<0.500		<0.500		<0.500		<0.0100	
Iron	mg/L	7439-89-6	31.2	2	94%	0	100%	<10.0		<0.200	
Lead	mg/L	7439-92-1	<0.500	<0.500		<0.500		<0.500		<0.0100	
Lithium	mg/L	7439-93-2	22.2	18.5	17%	17.5	21%	3.92	82%	0.0765	100%
Magnesium	mg/L	7439-95-4	660	550	17%	520	21%	101	85%	1.48	100%
Potassium	mg/L	7440-09-7	630	520	17%	489	22%	106	83%	3.71	99%
Selenium	mg/L	7782-49-2	<1.50	<1.50		<1.50		<1.50		<0.0300	
Silver	mg/L	7440-22-4	<1.00	<1.00		<1.00		<1.00		<0.0200	
Sodium	mg/L	7440-23-5	56500	47000	17%	44500	21%	8800	84%	126	100%
Strontium	mg/L	7440-24-6	810	650	20%	630	22%	107	87%	1.41	100%
Chloride	mg/L	16887-00-6	104000	91700	12%	96600	7%	15000	86%	239	100%
Nitrate as N	mg/L	14797-55-8	<50.0	<50.0		<50.0		<10.0		<0.100	
Fluoride	mg/L	16984-48-8	<250	<250		<250		<250		<0.500	
Nitrite as N	mg/L	14797-65-0	<50.0	<50.0		<50.0		<10.0		<0.100	
Sulfate	mg/L	14808-79-8	561	535	5%	537	4%	88.6	84%	1.42	100%
Ammonia	mg/L	7664-41-7	659	606	8%	614	7%	125	81%	2.80	100%
Gross Alpha	pCi/L	12587-46-1	<1790	<1490		1770G		<192		<3.55	
Gross Beta	pCi/L	12587-47-2	1460	1080	26%	478	67%	113	92%	1.63	100%
Radium-226	pCi/L	13982-63-3	68.2	43.4	36%	90.7	-33%	45.5	33%	0.136	100%
Radium-228	pCi/L	15262-20-1	328	126	62%	246	25%	44.1	87%	0	100%
Chemical Oxygen Demand	mg/L	STL00070	1940	2140	-10%	2500	-29%	248	87%	0	100%
Alkalinity	mg/L	STL00171	252	204	19%	190	25%	42.1	83%	18.3	93%
Bicarbonate Alkalinity as CaCO3	mg/L	STL00138	252	204	19%	190	25%	42.1	83%	18.3	93%
Carbonate Alkalinity as CaCO3	mg/L	STL00154	<4.00	<4.00		<4.00		<4.00		<4.00	
Hydroxide Alkalinity	mg/L	STL00127	<4.00	<4.00		<4.00		<4.00		<4.00	
Phenolphthalein Alkalinity	mg/L	STL00188	<4.00	<4.00		<4.00		<4.00		<4.00	
Specific Conductance	mho/cm @ 2	STL00244	201000	193000	4%	196000	2%	41900	79%	894	100%
Total Dissolved Solids	mg/L	STL00242	184000	168000	9%	179000	3%	28100	85%	485	100%
Total Suspended Solids	mg/L	STL00161	152	54.4	64%	61.9	59%	9.00	94%	0	100%
pH	SU	STL00204	6.1HF	7.0HF		7.0HF		7.3HF		7.4HF	
Temperature	Degrees C	STL00038	14.0HF	14.1HF		15.1HF		14.8HF		14.7HF	
Total Organic Carbon	mg/L	7440-44-0	<1.00	<1.00		<1.00		<1.00		<1.00	
C6-C12 Range Hydrocarbons	mg/L	STL00061	<5.00	<4.97		<5.08		<4.93		<4.87	
>C12-C28 Range Hydrocarbons	mg/L	STL00035	<5.00	<4.97		<5.08		<4.93		<4.87	
>C28-C35 Range Hydrocarbons	mg/L	STL00147	<5.00	<4.97		<5.08		<4.93		<4.87	
Total Petroleum Hydrocarbons (C6-	mg/L	STL00006	<5.00	<4.97		<5.08		<4.93		<4.87	

Analysis was done per step to determine what was removed at each step of the process.
This process allows us to look to specific treatment steps if we notice a breakthrough by a contaminant. We can also tailor each step to more efficiently remove the analytes that are targeted.

- **Metals**
  - An avg 88% removal of metals before reaching RO
- **Chlorides**
  - 86% removal prior to RO (104K – 15K)
- **COD**
  - COD shows an increase likely from chemical treatment used prior to desalination. Once it undergoes Freeze Desalination, COD is reduced by 87%
- **Alkalinity**
  - Avg 83% removal of bicarbonate alkalinity in-line with metals and solids removal
- **Suspended and Dissolved Solids**
  - Suspended solids are primarily removed during O&G pre-treatment, while dissolved solids decrease in linear relationship to metals and chlorides
- **Radionuclide**s
  - Radionuclides are partially removed during the initial O&G treatment, and decrease in linear fashion through the system until they reach RO which removes most remaining radionuclides and metals.
  - Polishing via media and GAC will be necessary to reach discharge standards
- **TPH**
  - TPH will naturally float to the top of the fluid during storage. Since samples are not taken from the top due to issues testing water with a noticeable oil sheen, TPH was not detected.
  -
- **VOCs** were analyzed separately pre and post GAC. In the large scale plant, we will be utilizing an RO followed by GAC (granular activated carbon filters)

PHASE 2: KEY FINDINGS

Phase 2 operated under an RRC Land Application Pilot Permit from May - Dec of 2024. Alfalfa was irrigated with 200-300 Gal. of water daily.
Control was changed to Midland groundwater, a more likely alterative water source.
Continued focus was placed on soil health throughout the study as well as more in-depth investigation into water quality.

WET TESTING

- WET testing was performed on the effluent until polishing requirements were finalized.
- Toxicology was also performed on plant samples at NMSU.
- Blending of concentrate has ceased.

NPDES+

- TPWR tested the NPDES+ list with NMSU & TTU to quantify as many regulated and non-regulated analytes as possible.
- TPWR tested over 500 different analytes in PW.
- 625 of the 711 test ran were non-detect results in the effluent.

RESEARCH

- TPWR has partnered with NMSU to publish research from phase 1, and TTU to publish research from phase 2.
- Internally, TPWR is researching opportunities for brine valorization, utilization of nat. gas. power, and alternative uses for treated water.

- WET testing results from Aug ‘24 validated that a final polishing step would be required for all post RO water that would be discharged to surface water.
- Survival rates the ceriodaphnia dubia in water prior to installing the Post RO GAC were not successful above a 50% dilution in a 6-day test.
- Water used for testing was 116 TDS and was remineralized by the laboratory prior to testing.

Aug ‘24

Summary of the 7-day Fathead Minnow Survival and Growth		
Concentration	Percent Survival	Mean Growth (mg)
Control	100	0.611
6.25 %	97.5	0.610
12.5 %	100	0.633
25 %	100	0.648
50 %	100	0.660
100 %	100	0.718

Summary of the 6-day *Ceriodaphnia dubia* Survival and Reproduction Data		
Concentration	Percent Survival	Mean Reproduction
Control	100	43.7
6.25 %	100	41.0
12.5 %	100	39.1
25 %	100	38.1
50 %	90.0	32.3
100 %	100	38.8

Method 1000.0 Chronic *Pimephales promelas* (Fathead minnow) Survival and Growth Test: The following were concluded from the test:

Survival:	**NOEC**	**LOEC**	**Growth:**	**NOEC**	**LOEC**	**IC25**
	100	>100		100	>100	>100

Method 1002.0 Chronic *Ceriodaphnia dubia* Survival and Reproduction Test: The following were concluded from the test:

Survival:	**NOEC**	**LOEC**	**Reproduction:**	**NOEC**	**LOEC**	**IC25**
	100	>100		100	>100	>100

November ‘24

Summary of the 7-day Fathead Minnow Survival and Growth		
Concentration	Percent Survival	Mean Growth (mg)
Control	97.5	0.951
6.25 %	100	0.864
12.5 %	95.0	0.927
25 %	92.5	0.916
50 %	97.5	0.935
100 %	97.5	0.927

Summary of the 6-day *Ceriodaphnia dubia* Survival and Reproduction Data		
Concentration	Percent Survival	Mean Reproduction
Control	100	32.6
6.25 %	100	29.9
12.5 %	100	34.7
25 %	100	33.1
50 %	100	33.8
100 %	90.0	25.5

Method 1000.0 Chronic *Pimephales promelas* (Fathead minnow) Survival and Growth Test: The following were concluded from the test:

Survival:	**NOEC**	**LOEC**	**Growth:**	**NOEC**	**LOEC**	**IC25**
	100	>100		100	>100	>100

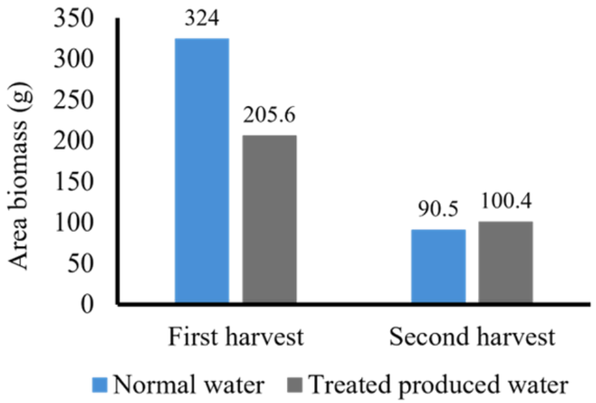
Method 1002.0 Chronic *Ceriodaphnia dubia* Survival and Reproduction Test: The following were concluded from the test:

Survival:	**NOEC**	**LOEC**	**Reproduction:**	**NOEC**	**LOEC**	**IC25**
	100	>100		100	>100	>100

PHASE 2: FINDINGS CONT.

Differences in Biomass

Normal water was better for early growth, but treated produced water allowed more sustained productivity over multiple harvests.



Research continues on soil differences, mineral uptake, nutritional comparison, and microbial activity.

Alfalfa grown with produced water improved in forage quality throughout the duration of the study, while the groundwater control side declined.

PHASE 2B: PLANS

Restoration

TWS will be applying for a 100 ac Land Application permit for a restoration style project in Orla, TX. This project aims to restore native brush grasses and will be done in conjunction with TPWRC and QuailSafe, LLC.

Surface Water Discharge

TWS has applied for tiered 23-100k BPD discharge permit to the Salt Creek through TCEQ. Water Quality has met TCEQ's current discharge standards but will likely require remineralization.

Commercial Development

Scaling up of the desalination facility will present more opportunity for commercial partnership and more accurate cost, power, and disposal requirements for full scale systems.

Gas Power Opportunities

Nat. gas power generation can present many opportunities in the form of reduction of operating cost as well as waste heat capture.

NEXT STEPS

While TWS is moving forward in development of their 10K BPD site, there are still hurdles that TWS and Beneficial Reuse as a whole will need to work out to guarantee long term success and implementation in the Permian.

Power

Most desalination methods require 5-50kwH/BBL meaning large scale power infrastructure or generation will be required.

Brine/Solids management

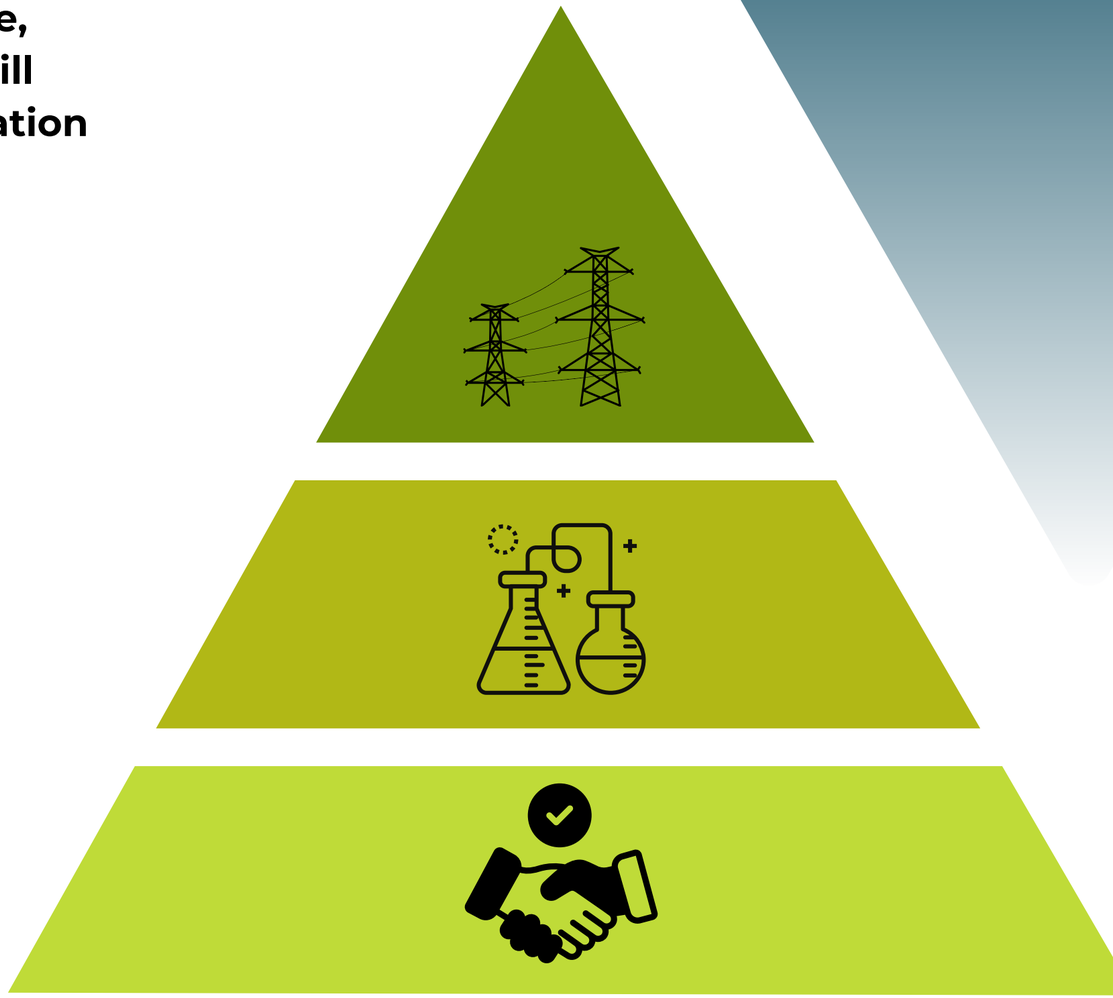
Desalination will produce either concentrated brine or solids.
For Example, a 10,000BPD site processing 120,000mg/L PW would hypothetically produce:

- ~4200 BBls of 240,000mg/L brine.
- OR 210 tons of solids daily

Management of high density brine or solids, either by disposal or resource recovery will be required.

Operator Partnerships

Significant capital investment and operator commitments will be necessary to facilitate near-future large scale implementation.



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THANK YOU

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