Advanced Water Treatment with the City of Scottsdale
Design of $27M RO Facility and DPR Project

REVERSE OSMOSIS
TECHNOLOGY SESSION

BEN LEE, P.E.
DAVID KOPCHYNSKI, PH.D., P.E.

FEBRUARY 27TH, 2020

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OUTLINE

- ACKNLOWLEDGEMENTS - SCOTTSDALE WATER
- ADVANCED WATER TREATMENT PLANT (AWT) OVERVIEW
- AWT REVERSE OSMOSIS (RO) PRETREATMENT FACILITIES
- AWT RO DESIGN
- O&M DISCUSSION FOR AWT RO
- THOMAS GROUNDWATER TREATMENT FACILITY - TGTF RO
- AWT AND DIRECT POTABLE REUSE (DPR)
- ADEQ DPR PERMITTING PROCESS
- QUESTIONS

TALK FOCUSED ON SCOTTSDALE WATER RO FACILITIES DESIGN AND DPR

ACKNOWLEDGEMENTS AND SCOTTSDALE WATER

- Special Thanks to:
  - **Rezaur Rahman, PH.D., P.E. Scottsdale Water - For Technical Content Assistance**
- Scottsdale Water
  - Providing Quality Drinking Water and Advanced Reclamation Services to Scottsdale Businesses and Residents for over 40 years
  - Service area, 185 Square Miles , Over 90,000 Active Water Accounts, 90 percent Residential Accounts, with 80,000 Active Sewer Accounts
  - Reclamation system - 1,400 miles of Sewer Collection Lines and Over 40 Lift Stations.
  - Advanced Water Treatment Facility (AWT)
    - Located at the Award-Winning Water Campus. Facility began operation in 1998
    - First Arizona Water Utility to Implement DIRECT Potable Reuse
    - One of the Largest and Most Sophisticated Reuse Facilities in the World.
    - An Industry Leader, and Employs RO Treatment

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ADVANCED WATER TREATMENT PLANT (AWT) OVERVIEW

AWT OVERVIEW

- Primary Performing Indirect Potable Reuse – Recharging Purified Recycled Water into Drinking Water Aquifers.
- AWT Finished Water, Often Referred to as RO permeate, is then:
  - Injected into a Series of Dry Wells or sent to the Reclaimed Water Distribution System (RWDS)
  - Flows through an Vadose Zone Soil Column - Soil Aquifer Treatment (SAT),
  - Finally Reaching the Drinking Water Aquifer.
- Annually, Scottsdale Recharges over 1.7 Billion Gallons of Purified recycled Water to Replenish Drinking Water.
- Primarily with AWT, Scottsdale has Recharged over 70 Billion Gallons into Regional Aquifers Since 1988.
- RO treatment within AWT Plays the Critical Role
- Water produced by AWT is Considered Ultrapure
- AWT has 20 MGD RO Permeate Capacity

AWT UNIT TREATMENT PROCESSES

- At Water Campus – Tertiary Filtration, Ozonation, Chlorination
- At AWT
  - Influent Pumping Strainers
  - Ultrafiltration – Upgraded from Microfiltration
  - Pre RO Chemical Conditioning
  - Cartridge Filtration
  - High Pressure Pumping
  - RO System
  - Chemical Conditioning
  - UV Photolysis

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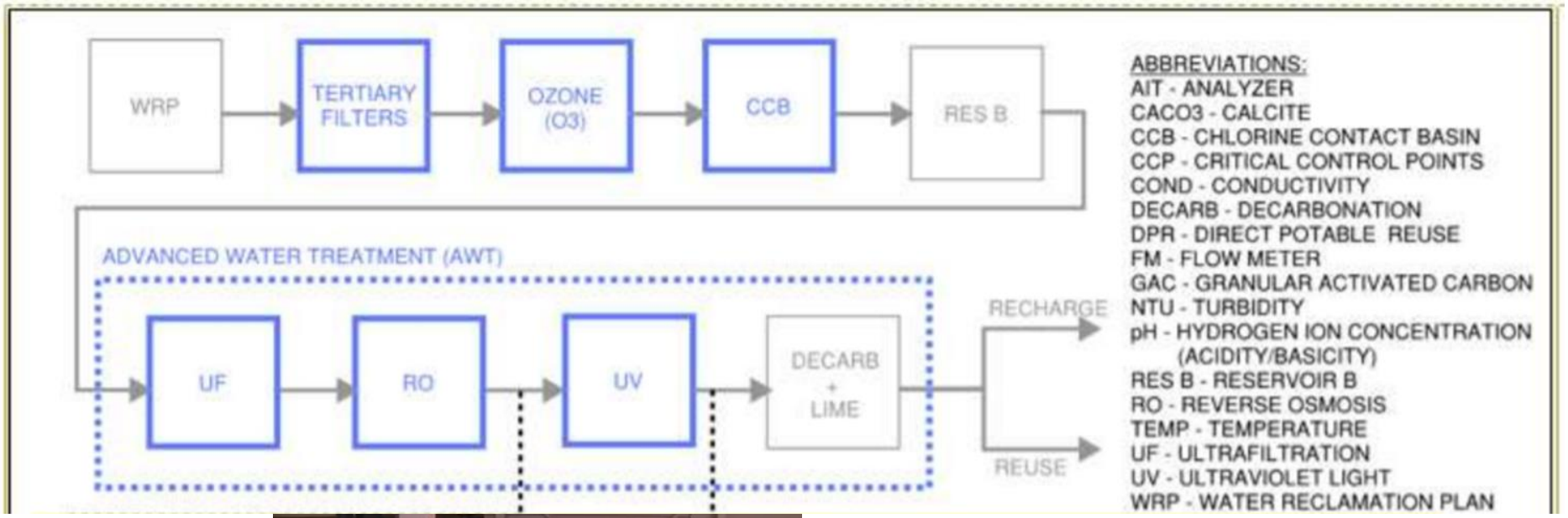
AWT OVERVIEW



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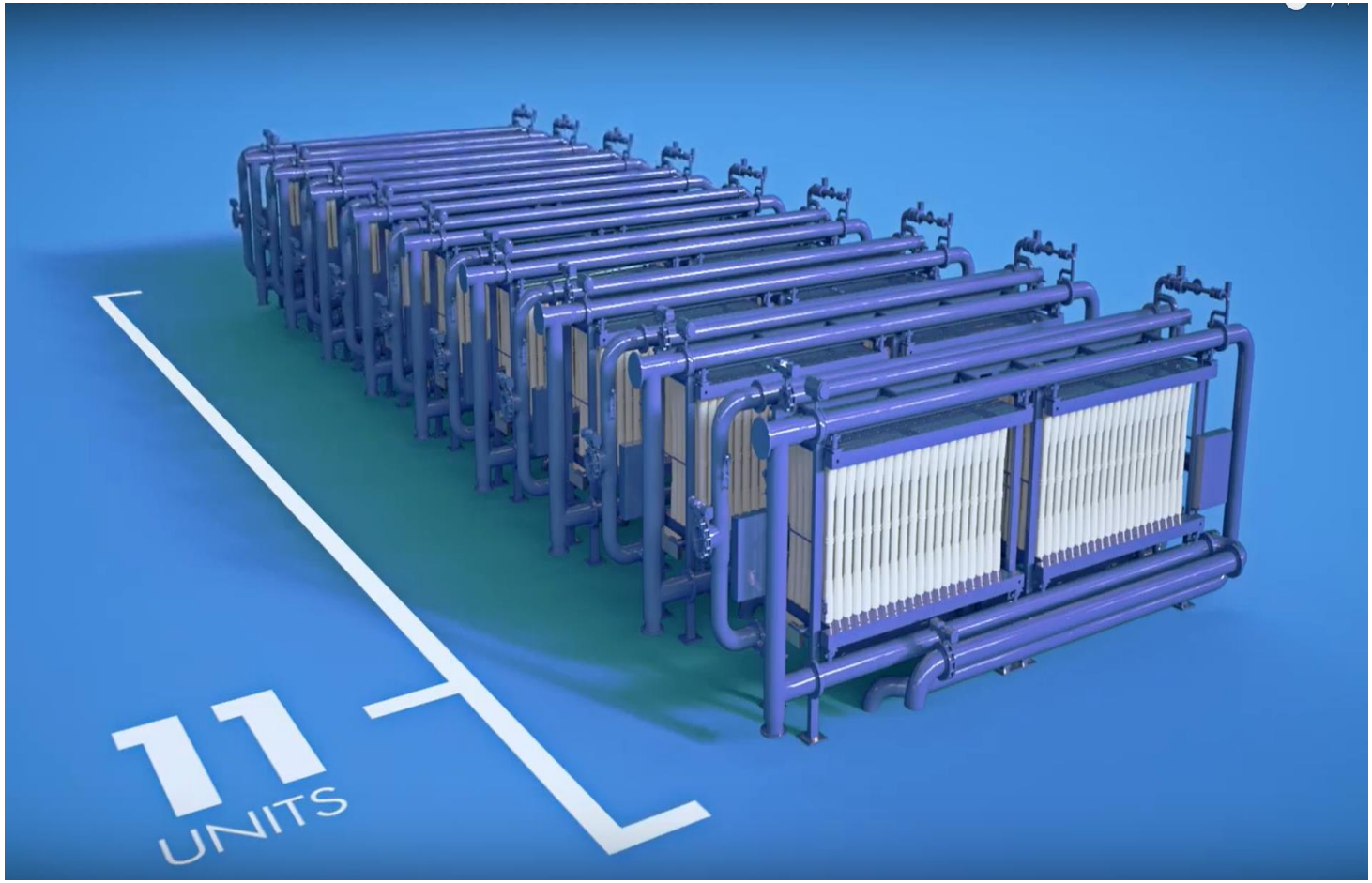
AWT ULTRAFILTRATION



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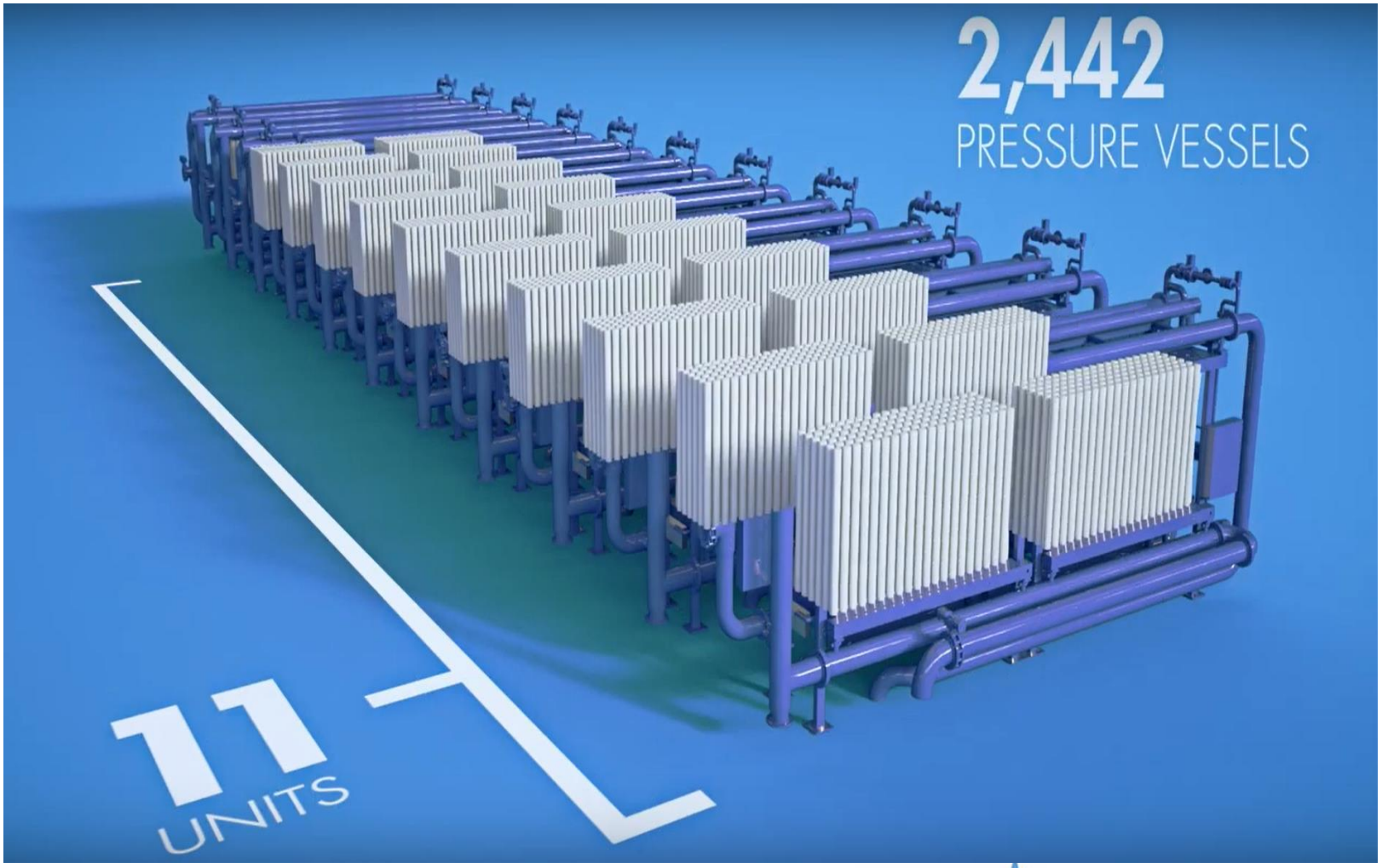

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AWT ULTRAFILTRATION

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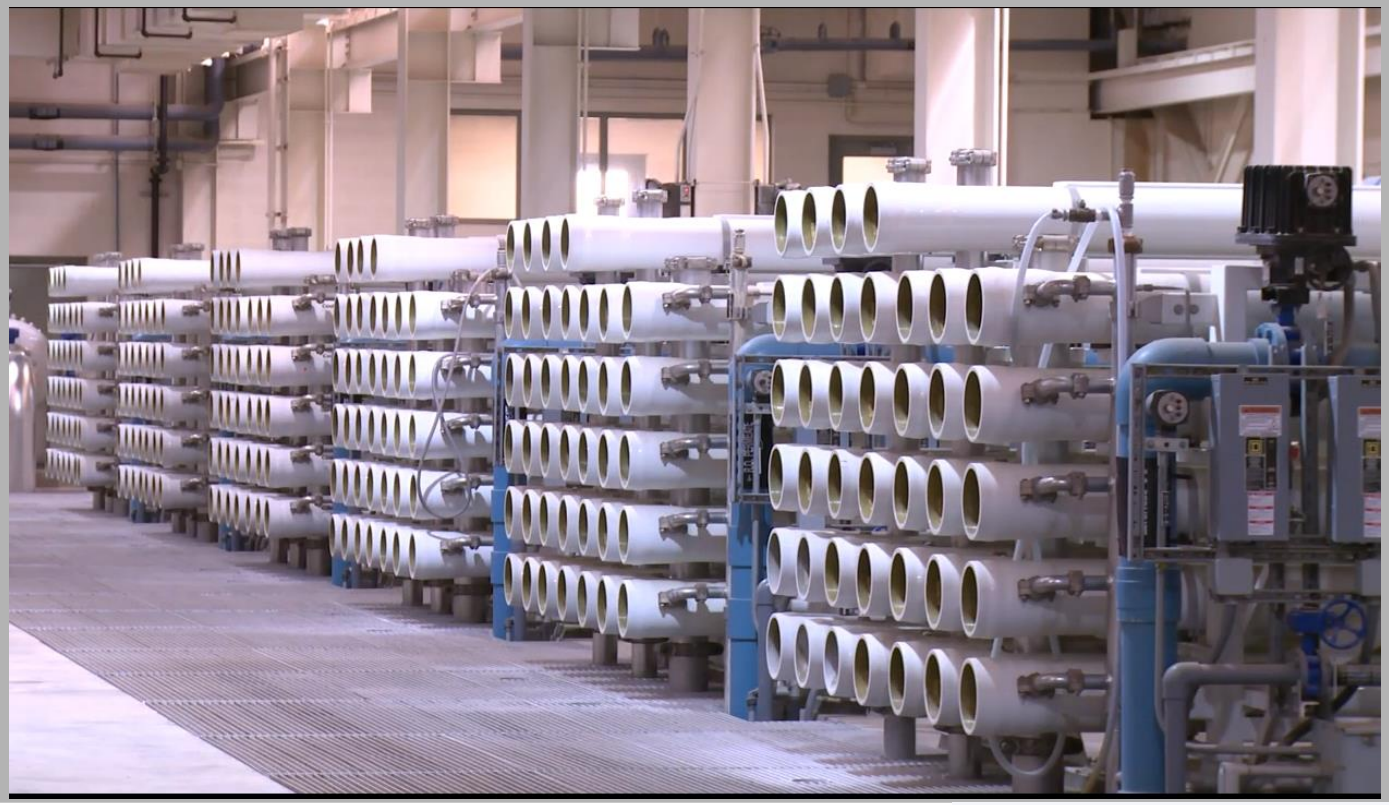
CARTRIDGE FILTRATION

- Significant Pretreatment Provided in Front of RO
- Help to protect RO System from Upstream Process Upsets
- Mixing Zone for Addition of Threshold Inhibitor and Sulfuric Acid

Cartridge Filters

Parameter	Value
Number	5
Type	Wound Polypropylene
Tag	CF-1, CF-2, CF-3, CF-4, CF-5
Flow per Filter, gpm	1,735
Manufacturer	Parker Process Filtration
Cartridge Model	M15R40A
Inner Diameter (in)	1
Outer Diameter (in)	2.5
Housing Model	MP 118H-4-12FKI
Filter Mesh, microns	5
Pressure Drop, psi/filter	5
Effective particles filtration size, microns	20

AWT REVERSE OSMOSIS (RO)



AWT RO UNITS

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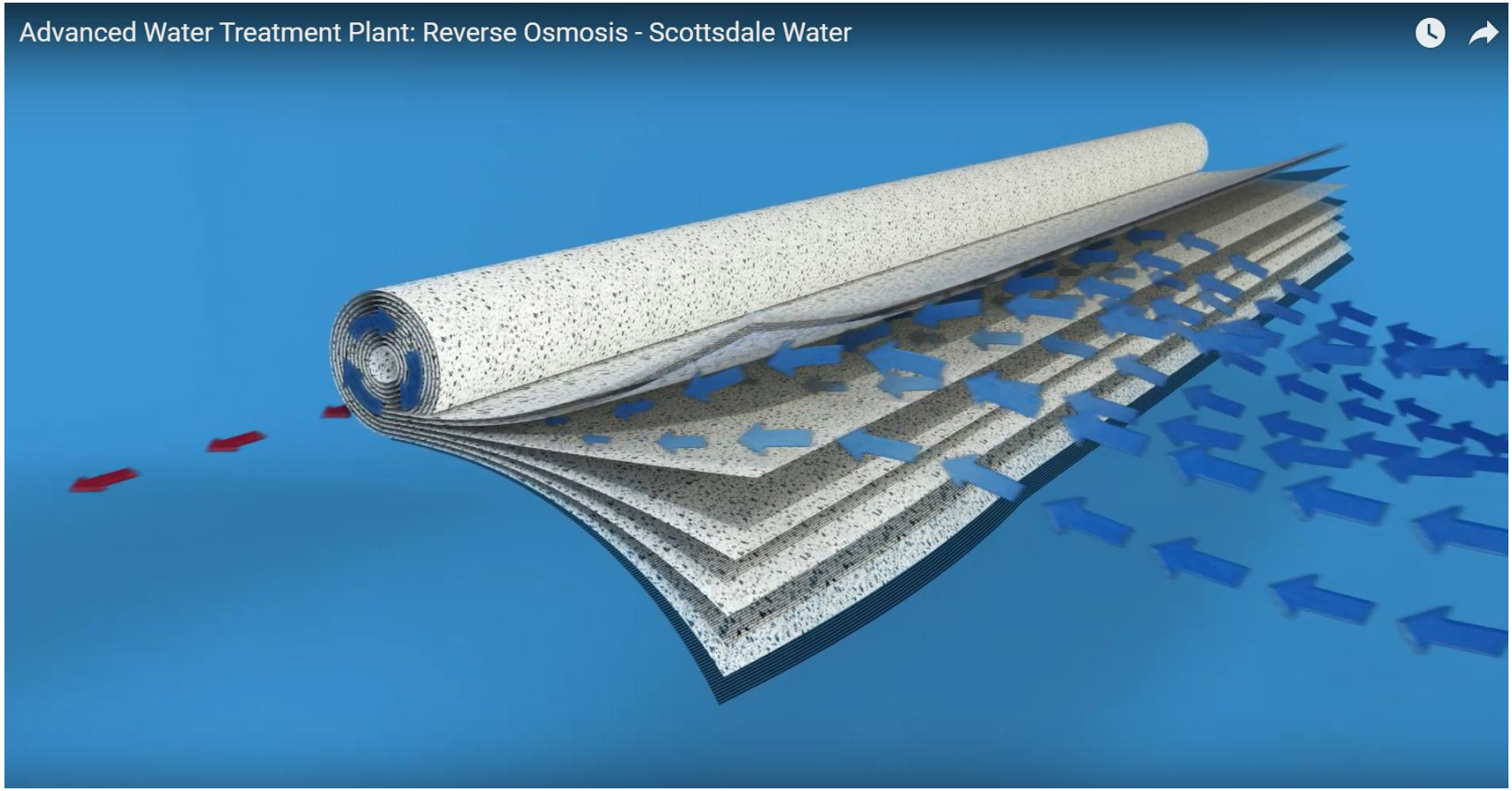
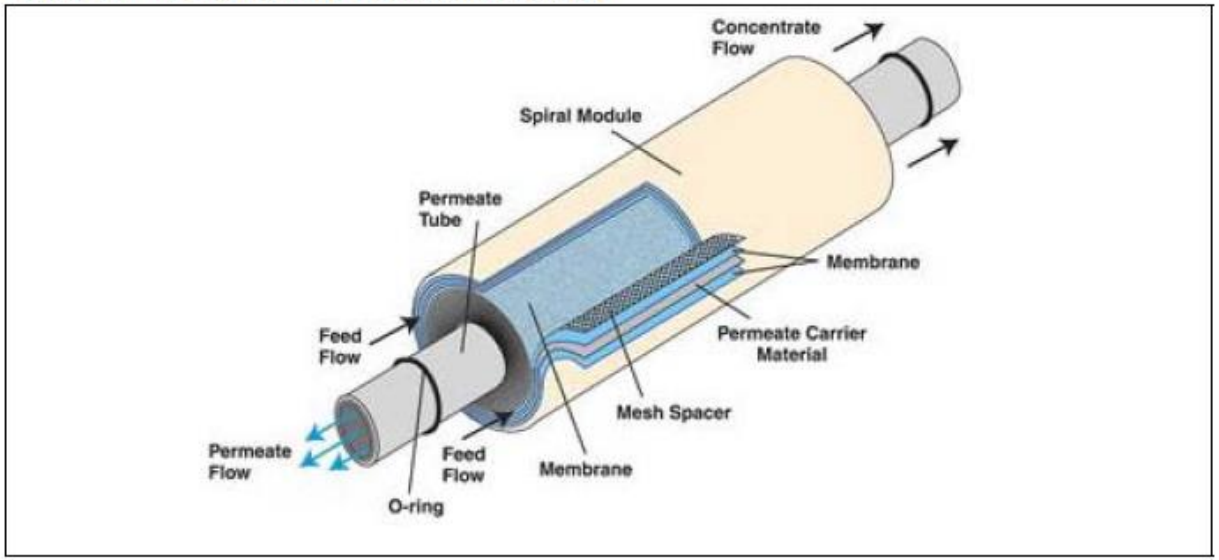
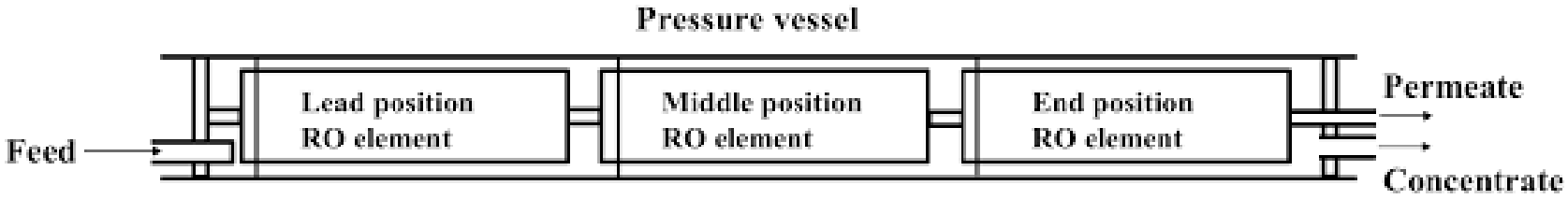
RO MEMBRANES



RO MEMBRANE ELEMENTS & PRESSURE VESSELS

Figure 10 Reverse Osmosis Membrane Element





RO SYSTEM DESIGN HIGHLIGHTS

- Upgraded in 2012 – Add 7 MGD Capacity to get to 20 MGD RO Permeate Production
- 14 Original Trains using 8-inch Elements – 12 MGD
- Supplemented with Three Additional Trains using Large Diameter 16-inch Elements – 8 MGD
- Large Dia. Elements Allowed Expansion of RO with Reduced Footprint Requirement

Table 2 RO Unit Array Configurations

	Existing Arrays	16 inch Nominal Dia.	18 inch Nominal Dia.
Vessels 1st:2nd:3rd	24:10:5 20:10:5	14:6 -	11:5 -
Rows	6	4	4
Elements per vessel Standard 60 inch long	 6 4	 7 -	 - 5
Elements per train Standard 60 inch long	 210 to 234 140 to 156	 140 -	 - 80
Design Feed Rate, gpm	800 700	1944 -	1944 -
Design Feed Pressure, psi	145-300	145-265	145-265
Plan dimensions ft x ft	22.5 x 10	29.5 x 14	31 x 11.5
Footprint capacity, gpd/sf	4444	5811	5610

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AWT RO SYSTEM DESIGN HIGHLIGHTS

- Three New Cartridge Filters Added
- New Stainless Steel Piping for RO Units
- New Sulfuric Acid Dose Pump and Piping
- New Threshold Inhibitor Dose Pump and Piping
- Two new RO Permeate Storage Tanks and new RO Flush Pumps
- New CIP Tank, Controls, Piping, Valves
- Three New Large Diameter RO units
- Replacement of Membranes in Existing RO Trains

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AWT RO SYSTEM COSTING

- 2012 Bid Information
- 2012 Engineers Estimate of Costs
  - 10.5 million Dollars for Project Equipment
  - New Large Diameter RO Units 2.1 Million Dollars Each

	8 inch Nom Dia.	16 inch Nom Dia.	18 inch Nom Dia.
Elements (40 inch long), $			
Low	$375	$1573	$2975 (est.)
High	$417	$1655	
Elements, $/sq ft			
Low	$0.938	$0.983	$1.044 (est)
High	$1.044	$1.034	
Vessels, $ each	N/A	$4950	$6550 (est)
RO Unit Installed	N/A	$1,920,665	$1,943,276
Unit cost, $/gpd permeate		$0.269	$0.272

RO SYSTEM OPERATING PARAMETERS

General RO System Operating Parameters

Parameter	Design	Expected Range
Temperature, degrees C	25	20 to 32
RO Feedwater Conductivity, umho	716	500
RO Permeate Conductivity, umho	65	40-70
RO Feed Pressure, psi	200	100 to 300
RO Recovery, %	85	85
RO Feed pH	6.5	6.0 to 6.8
RO Permeate Flow per Train, mgd	0.85	0.68 to 0.94

AWT LARGE DIAMETER RO UNITS

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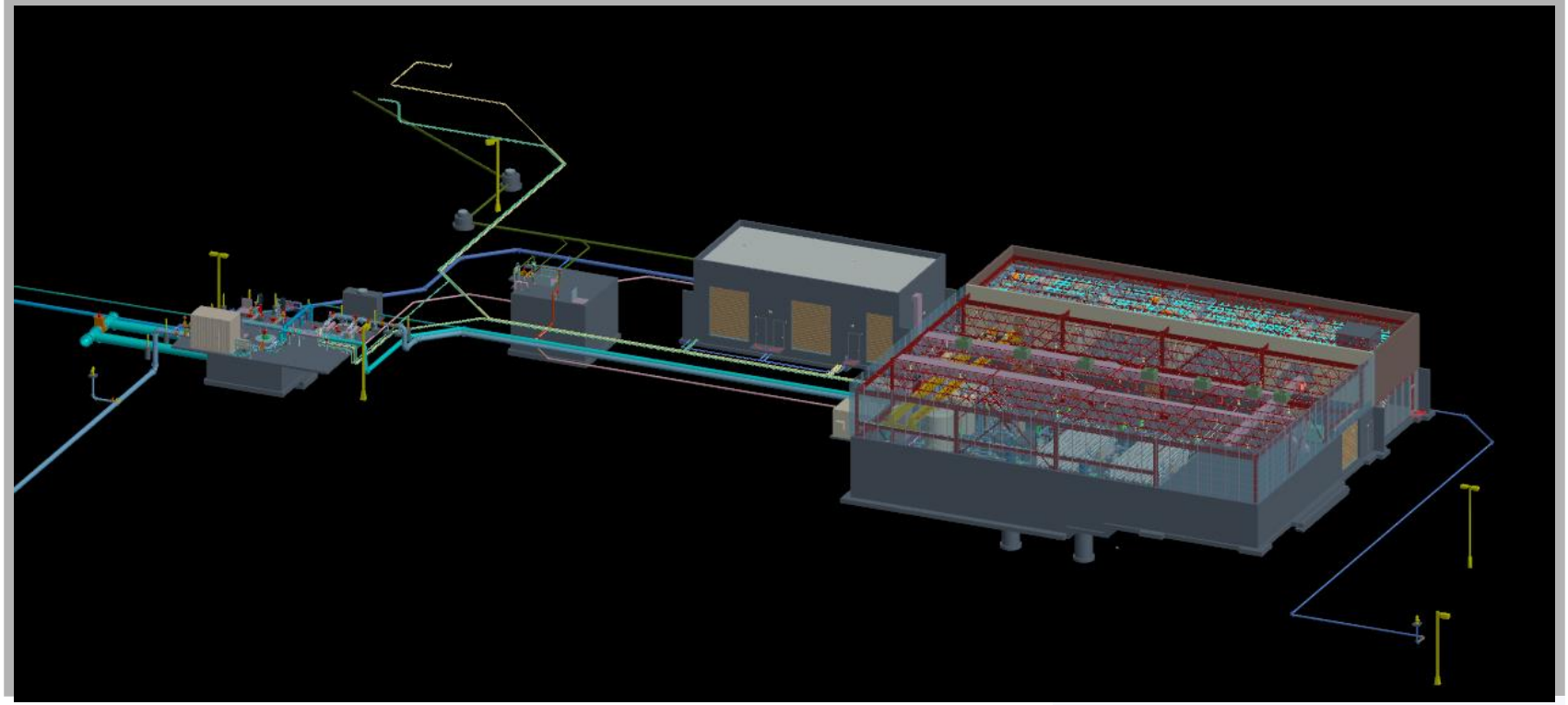
AWT RO OPERATION AND MAINTENANCE

- RO Concentrate – Discharge to Sewer – Ultimate Treatment at SROG 91st Avenue WWTP
- Larger Diameter Elements Require Special Equipment to Handle Safely with Operators
- RO Chemical Cleaning Frequency – Clean in Place (CIP), System Flushing
  - Add Various Softening Agents
  - Add Detergents to Emulsify Oils and Hydrophobic Foulants
  - Purge Concentrate with Permeate before Initiating CIP to Prevent Scaling
- RO Flushing for Shut Down – Permeate Needed - Normal vs. Emergency
- RO Membrane Element Replacement Frequency – For 8-inch Vessels Replacing Thin Film Composite Polyamide Elements with Thin Film Nanocomposite (TFN) Elements
- Power
  - Four 150 HP Pumps to Feed Ultrafiltration System Filtrate to RO
  - 200 HP High Pressure Pump per RO Train

THOMAS GROUND WATER TREATMENT FACILITY - TGTF



TGTF FACILITY HIGHLIGHTS

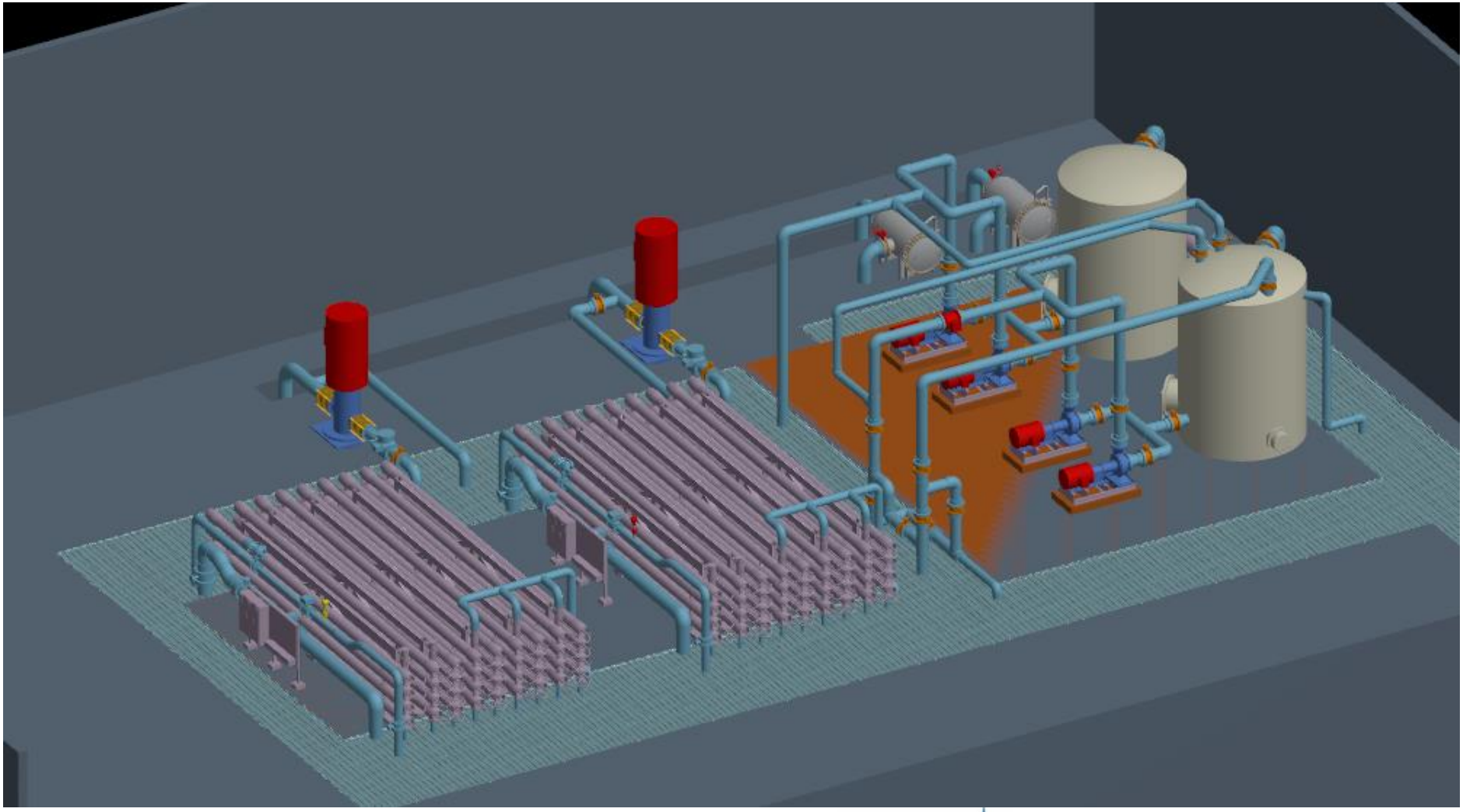
- Central Groundwater Treatment Facility (CGTF) Operating to Remove TCE and Other Groundwater Contaminants
- CGTF Discharge Meets Drinking Water Quality, BUT has O&M, Aesthetic Issues
- TGTF Using RO Treatment Implemented for Additional Treatment of a Portion of CGTF Finished Water to Remove:
  - TDS and Hardness
  - Contaminants of Potential Concern (CPCs) – Chromium (VI), Strontium, and 1,4-Dioxane
- TGTF Helps to Alleviate Precipitation of Sparing-Soluble Salts (e.g. Calcium Carbonate) in CGTF Stripping Towers and Water Distribution System
- TGTF Permeate Design Flow – 3.0 MGD
- Treated Water Sent into Water Distribution System

TGTF RO DESIGN

- 2 - 50 HP RO Feed Pumps with 2 - 250 HP High Pressure Pumps per RO Train
- RO Pretreatment:
  - Auto Strainers – 100 micron – Deal with CGTF Sand Silt Carry Over
  - Cartridge Filters – 10 micron
- Cold vs Warm Water Conditions and RO Membrane Age
  - 0 to 3 Year Old Membranes, 25 and 35 Degree C Feed Water
- 2 Stage RO in 2 Trains – 80% Water Recovery, Feed Pressure 160 – 195 psi
- Permeate Backpressure Valve to Throttle First Stage Flow to Help Balance Flux Rate between Stages, Forces Flow to Second Stage
- Automatic CIP/Flush System

Parameter, Unit	Value
Train Size, mgd	1.5
No. Trains, Duty + Standby	1 + 1
No. Stages	2
No. Pressure Vessels/First Stage	24
No. Pressure Vessels/Second Stage	12
No Pressure Vessels/Train	36

TGTF RO TRAIN LAYOUT



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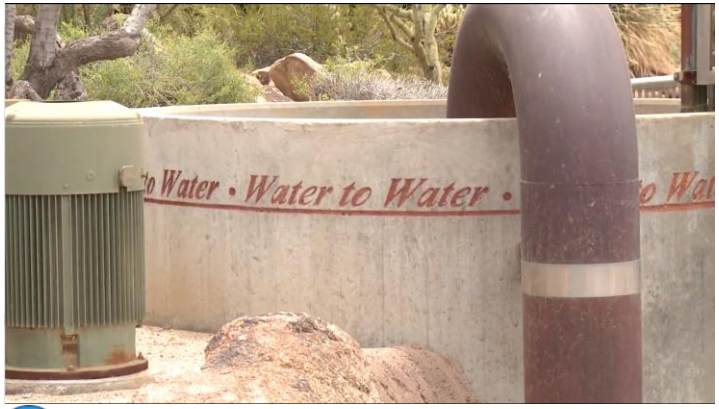
AWT AND DIRECT POTABLE REUSE (DPR)

AWT DPR PERMITTING TIME LINE

- Up until 2018, Statutory Preclusion in Arizona Against Use of Recycled Water for Direct Potable Use.
- Recognizing the Advances in Technology and Monitoring, State removed Direct Human Consumption Prohibition in January 2018.
- Has Opened the Door for Arizona Communities to Begin Process of Moving Toward Direct Potable Reuse (DPR) as a Viable Long-term Water Supply.
- July 2018 ADEQ asks for DPR Projects
- Oct. 2018 Scottsdale and ADEQ Start Interactions
  - Plan for Water Taps at AWT, One for Exterior Uses, Another for Tour Tasting
  - Monitoring Issues – Log Removal, Emerging Contaminants, Monitor before Water Distribution
  - Added Treatment, Including Redundant UV, GAC, Remineralization, and Chiller



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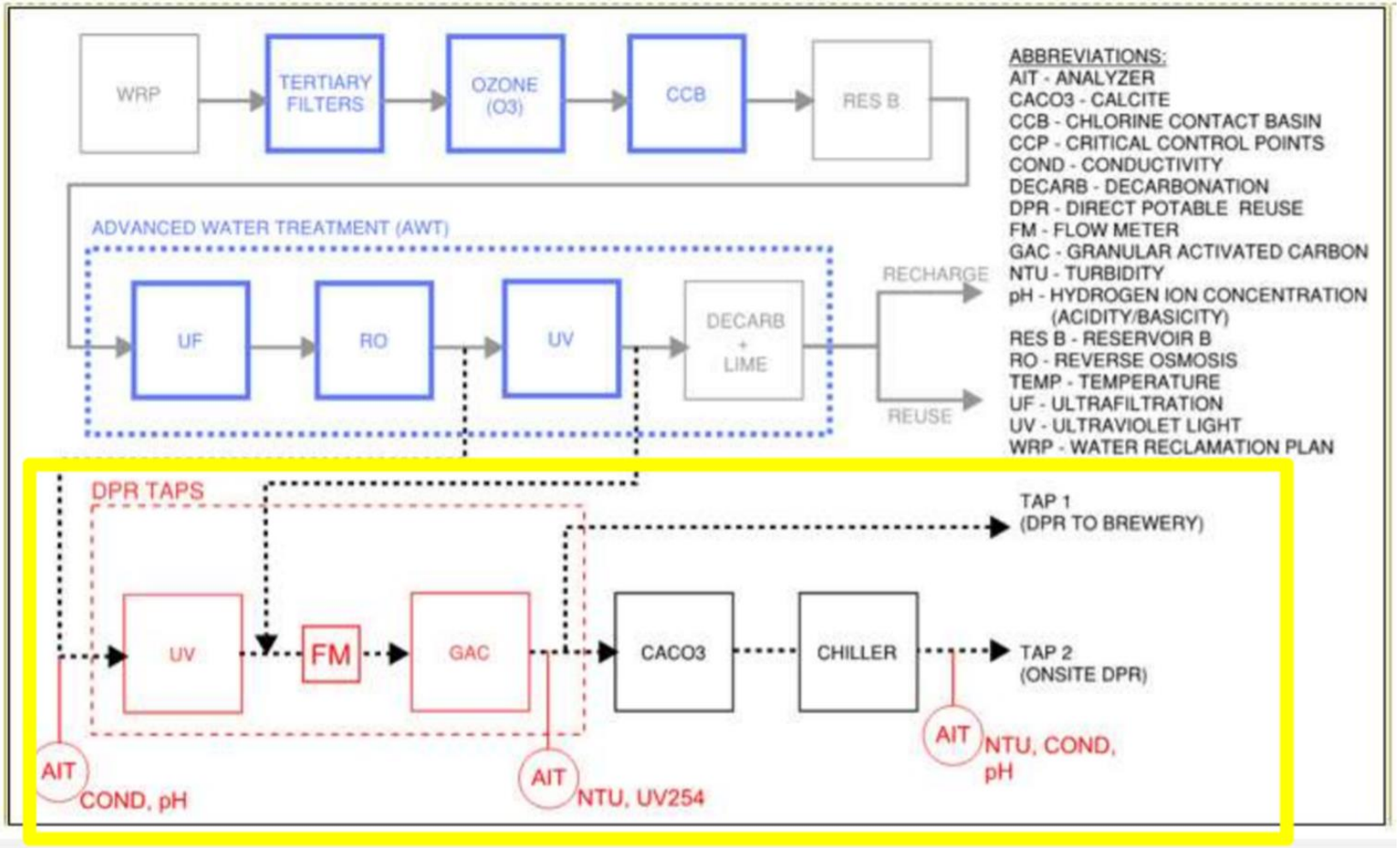
AWT DIRECT POTABLE REUSE



AWT TREATMENT SKID WITH TAPS FOR DPR

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AWT DPR PERMITTING TIMELINE

- February 2019 - Scottdale Submits Permit Application
  - Individual Water Permit
  - No Application Currently Available for DPR
  - Prepare Design Report Info
    - No Pilot Study – AWT Operating for over 20 years
    - Log Removal Credits 10/8/8 Split in Between California and Texas
    - Short List of Emerging Contaminants
    - Drinking Water Standards Monitoring
    - Process Control Monitoring Plan – Before Water is Released for Events
  - Challenges
    - Lab Analysis Licensing for Emerging Contaminants – Have to Send Samples Out
    - Water System Classification – Non Public vs. Public
    - Specific Operator Certification not Available – Training for Dual Wastewater and Water Certifications
    - Demonstrating Financial , Technical, and Management Capability
    - Source Water Location – Deemed at UF Influent, Log Removal Credit Source Water Starts at Tertiary Treatment

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AWT DPR PERMITTING TIMELINE

- April 2019 - Scottdale Submits Design Report and O&M
  - County Coordination – ATC/AOC not required program not delegated, No Drinking Water input since not a Public System, Prohibition is under Review.
- June 2019 – ADEQ Issues Draft Permit
- July 2019 - New Source Testing from UF, Results Submitted to ADEQ and Finished Water Sampling from DPR Skid Tap 1
- September 2019 - After 18 months of Working Closely to Create Criteria for Monitoring and Regulation of Purified Reclaimed Water, Scottsdale Water Issued the State's First Permit for DPR and only Third in the Nation.

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SCOTTSDALE WATER DPR – WHERE ARE WE NOW

- Scottsdale Water Will not be Sending Recycled Water into the Drinking Water System.
- Instead, Scottsdale Conitues to Meet Customer Needs through its Diverse Water supply Portfolio
- Continue Indirect Potable Reuse to Recharge the Aquifer for Future Beneficial Use.
- Other Cities Actively Pursuing DPR as a Long-Term Water Source can Employ Scottsdale Water's DPR Permitting Blueprint.
- BUT WAIT!!! There is More!

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DPR and BEER!

- Scottsdale has set up program to provide educational program and direct application for DPR via BEER!!
- One Water Brewing Show Case Held October 2019 Sponsored by Scottsdale Water and Scottsdale Arts
- Direct Potable Water Reuse Water Source from AWT Supplied to Local Craft Beer Brewers
  - Desert Monks Brewing Co.
  - O.H.S.O. Nano-Brewery
  - Uncle Bear's Brewery
  - Freak'N Brewing Company

  (in collaboration w/Dubina Brewing Co)
  - Wren House Brewing Co
  - Walter Station
  - Fate Brewing Co
  - Mother Bunch Brewing, Inc
  - North Mountain Brewing
  - Flying Basset Brewing

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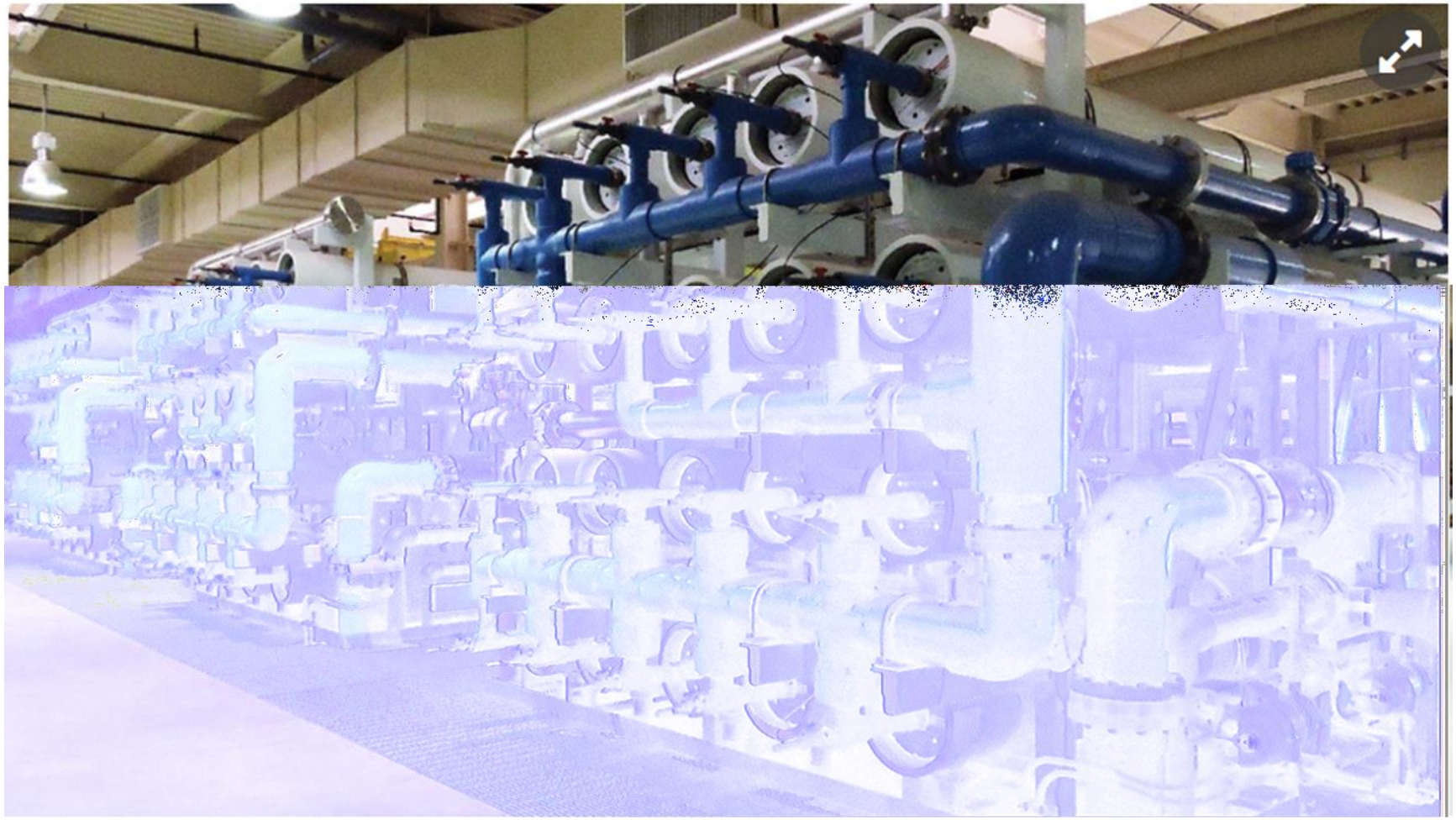
QUESTIONS



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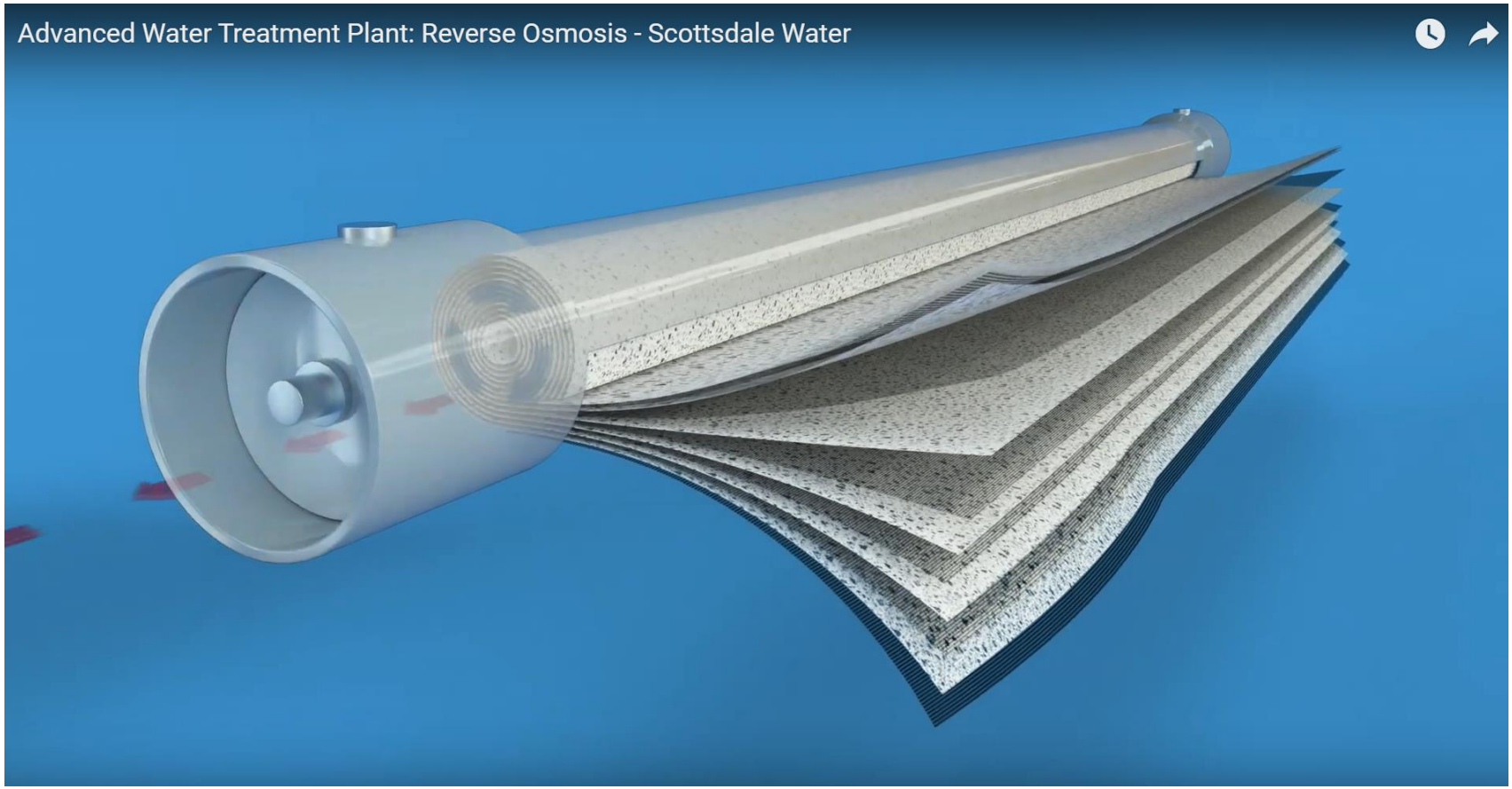
TGTF FEED WATER QUALITY

	Units	Min	Avg	Max
Primary Constituents				
Total Dissolved Solids	mg/L	902	1047	1138
Total Hardness	mg/L	550	610	651
Arsenic	µg/L	5.9	11.7	16.3
Nitrate	mg/L as N	7.0	7.1	8.0
Total Chromium	µg/L	6.8	9.0	22.3
Chromium (VI)	µg/L	7.7	8.2	10.0
Strontium	mg/L	1.5	1.7	1.9
1,4 Dioxane	mg/L	1.0	1.2	1.4

Supplementary Constituents				
Silica	mg/L	30.0	34.0	37.0
Bicarbonate Alkalinity	mg/L	212	213	228
Total Alkalinity	mg/L	174	200	228
Iron	mg/L	0.04	0.12	1.04
Chloride	mg/L	305	326	356
Calcium	mg/L	80.0	92.0	100
Magnesium	mg/L	84.0	93.0	99.0
Sodium	mg/L	172	192	1300
Barium	mg/L	0.06	0.06	0.08
Sulfate	mg/L	114	140	197
Fluoride	mg/L	0.4	0.7	0.8
Boron	mg/L	0.4	0.5	0.7
Potassium	mg/L	4.8	5.3	11.0
Additional Considerations				
pH	pH Units	7.3	7.8	8.5
Temperature	°C	25.0	30.0	33.0

RO MEMBRANES



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