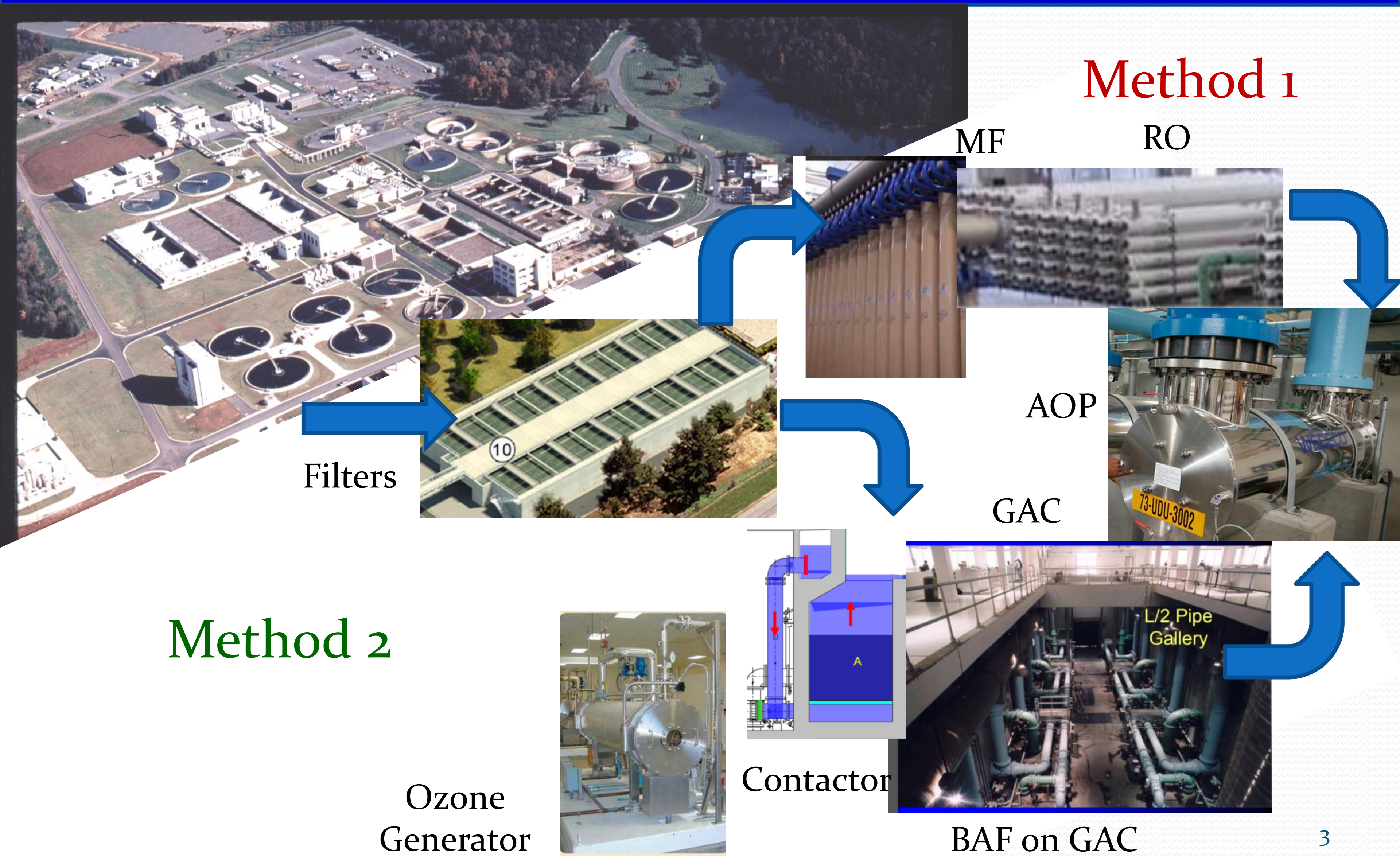
Moving Wastewater Systems towards Economic and Sustainable Reuse
Part III

Dipankar Sen, PhD, PE
Santa Clara Valley Water District
Professor, Virginia Tech Civil & Env Engr

Outline

- Changes in wastewater in our industry
- How it affects the wastewater treatment plant
  - Advanced Wastewater Treatment Configurations and their Operation
- Recycled water production
  - Configurations
  - Managing Risk – how will operations change?
- Ways to plan for the future

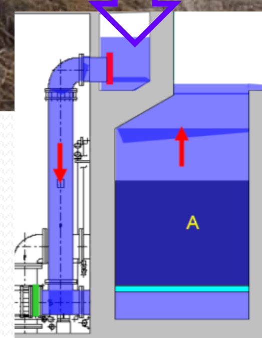
Two Methods to Get to Potable Reuse



Redlands MBR

Slide: Courtesy of City of Redlands;
Dave Commons; Membrane GE Zenon

Method 1



BAF on GAC

Method 2

Ozone
Generator

Two Examples for Producing Raw Supplies From Potable Reuse

Membrane Filtration – RO – Advanced Oxidation

<u>Questions you should ask</u>

- Method of brine (RO reject) disposal:
  - No treatment option?
  - treatment and management needed?
- Water loss due to inefficiency acceptable?
- Quality of water with which reuse product will be blended?
- Does TDS of product water or blended water need to be reduced?
- Type of buffer?
  - Engineered
  - Reservoir
  - Aquifer

Filtration – GAC – Disinfection

or

Filtration – Ozone-BAF on GAC – Disinfection

<u>Questions you should ask</u>

- Are specific inorganics an issue?
  - Metals like lead, copper, nickel, etc.
  - Fluoride, bromide, bromate, etc.
- Is TDS of product water or blended water acceptable?
- Are there other regulatory or public perception drivers for the project?

Reference: Sen, Angelotti, WEFTEC Proceedings, 2016

WEFTEC 2016, Workshop 13
New Orleans, Sep 24, 2016
Available from WEF

Moving from Conventional Treatment to Potable Reuses

Dipankar Sen, Director & Prof, Advanced Treatment & Reuse, Virginia Tech
Robert Angelotti, Director, Upper Occoquan Service Authority (UOSA)
Andrew Salveson, Director, Water Reuse, Carollo

Chris Stacklin's presentation
Daniel Nix's presentation

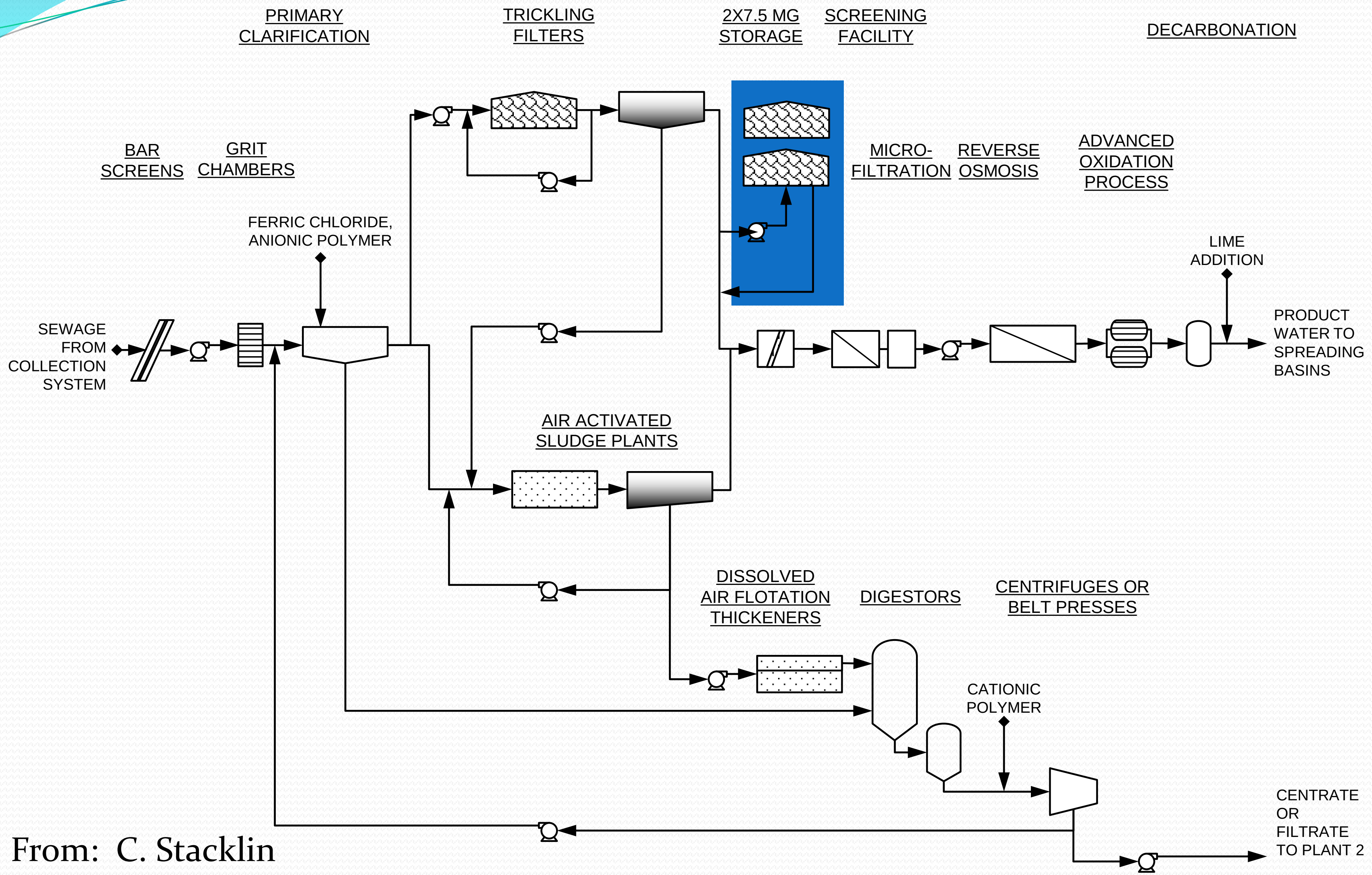
Bob Angelotti's Presentation

Silicon Valley Purification Center Videos on Youtube

https://www.youtube.com/watch?v=aYOGVpTsvRA
Discuss Options to upgrade AWTP in the future for Potable Reuse

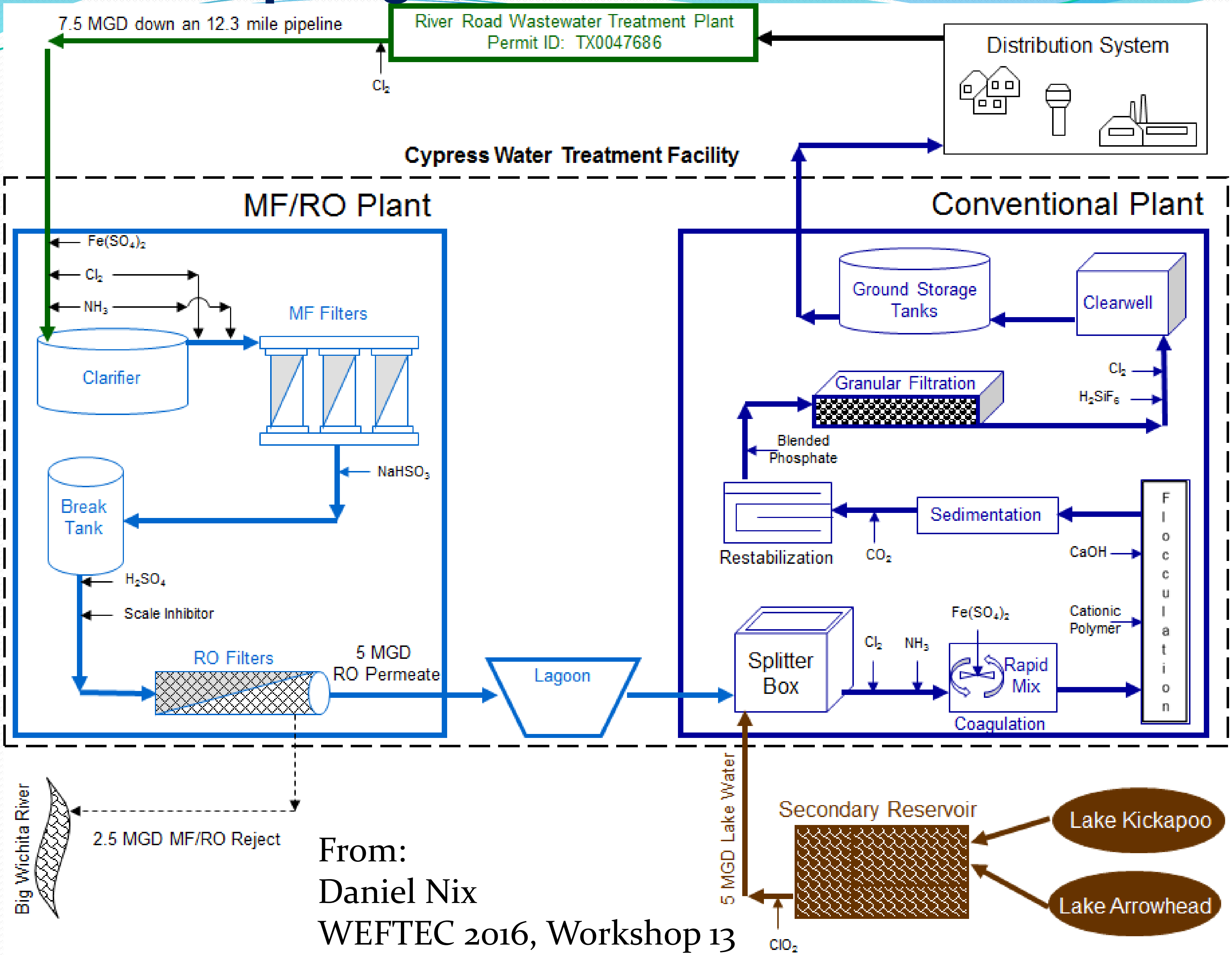
Membrane Based – MF & RO

OCSD – OCWD – Indirect Potable Reuse



From: C. Stacklin
WEFTEC 2016, Workshop 13

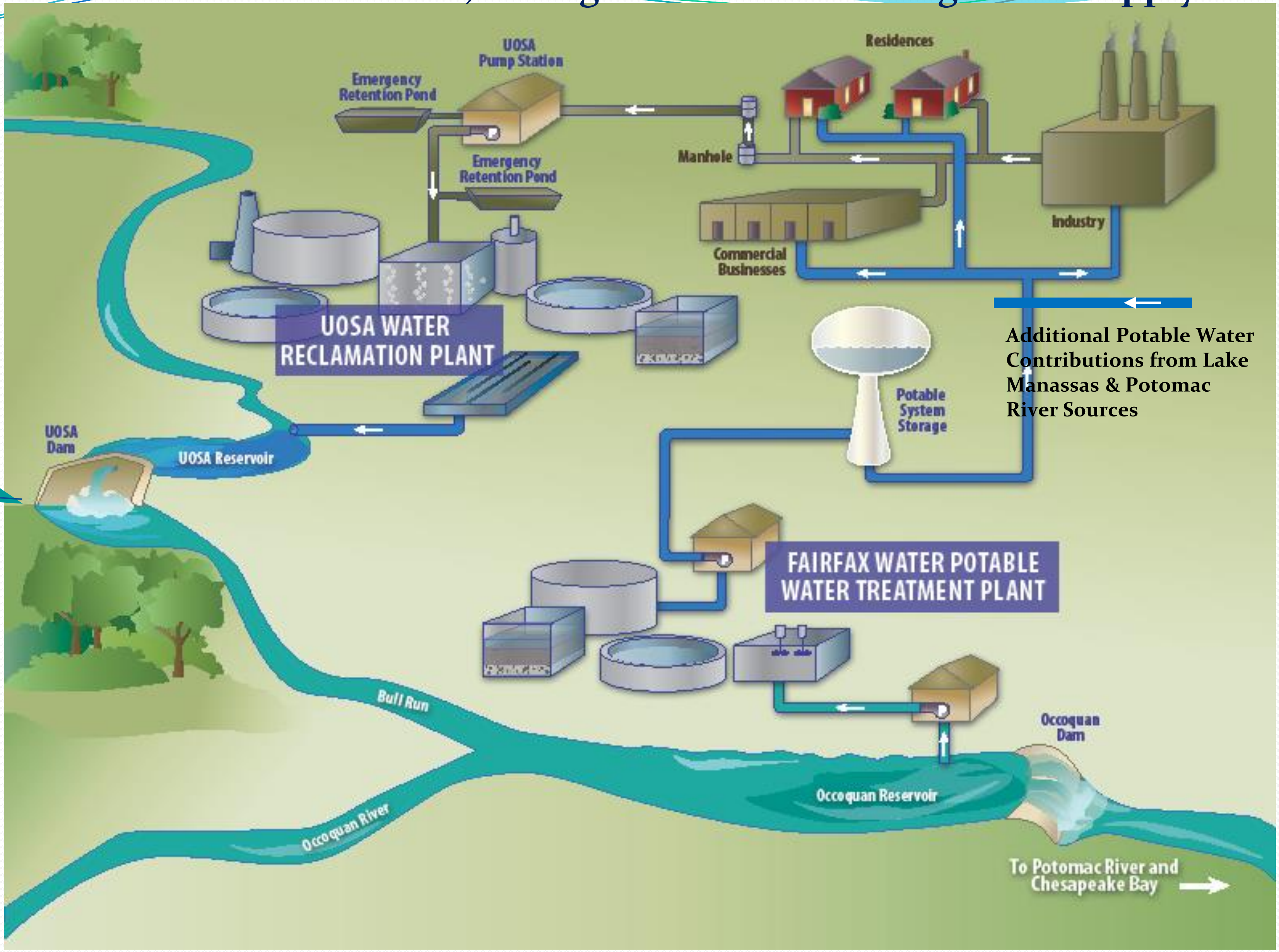
Wichita Springs, TX – Direct Potable Reuse



From:
Daniel Nix
WEFTEC 2016, Workshop 13

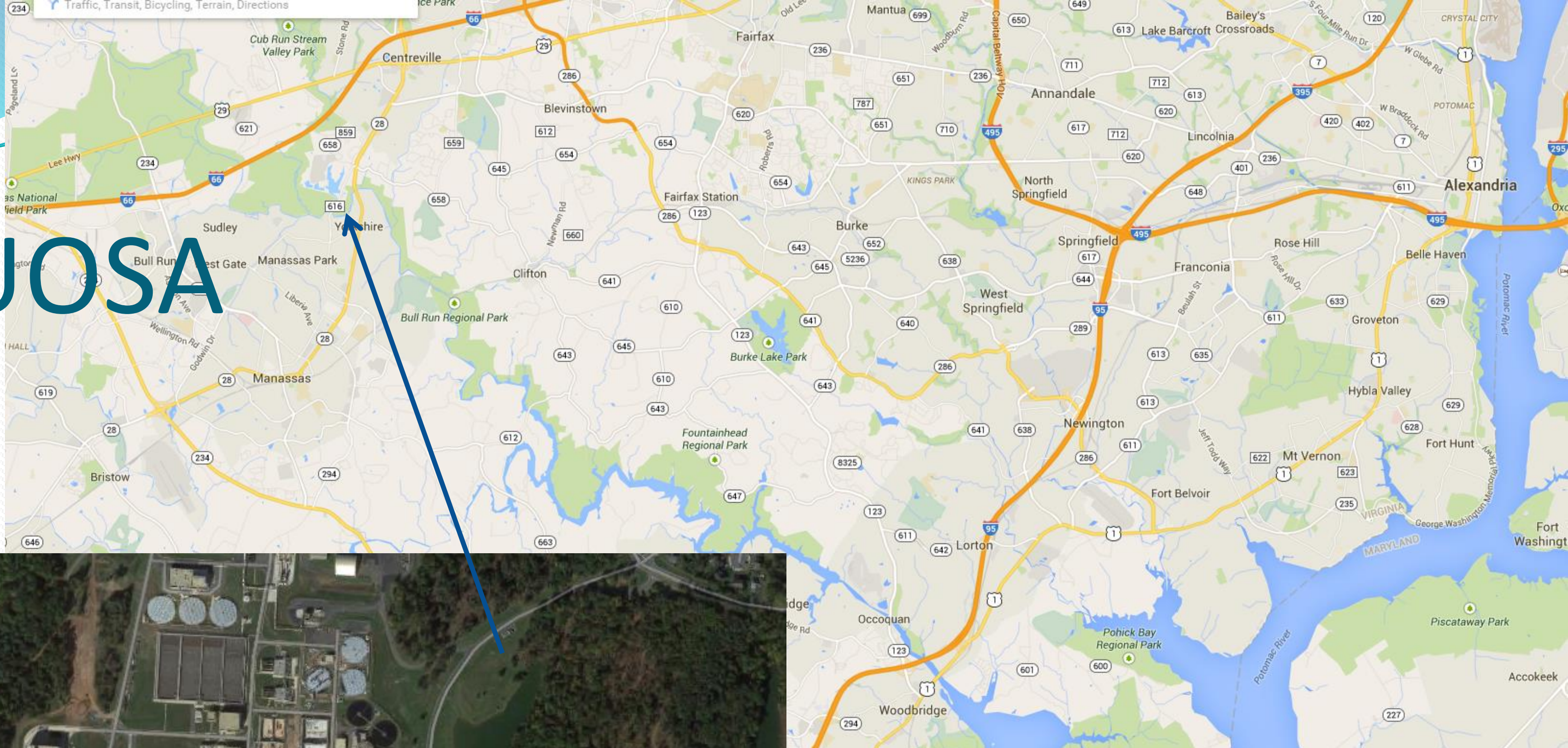
GAC or Ozone-BAF on GAC

UOSA, VA – Indirect Potable Reuse – 30 years of experience
All of the Effluent sent for Reuse, Average of 10 % of Drinking Water Supply



Additional Potable Water Contributions from Lake Manassas & Potomac River Sources

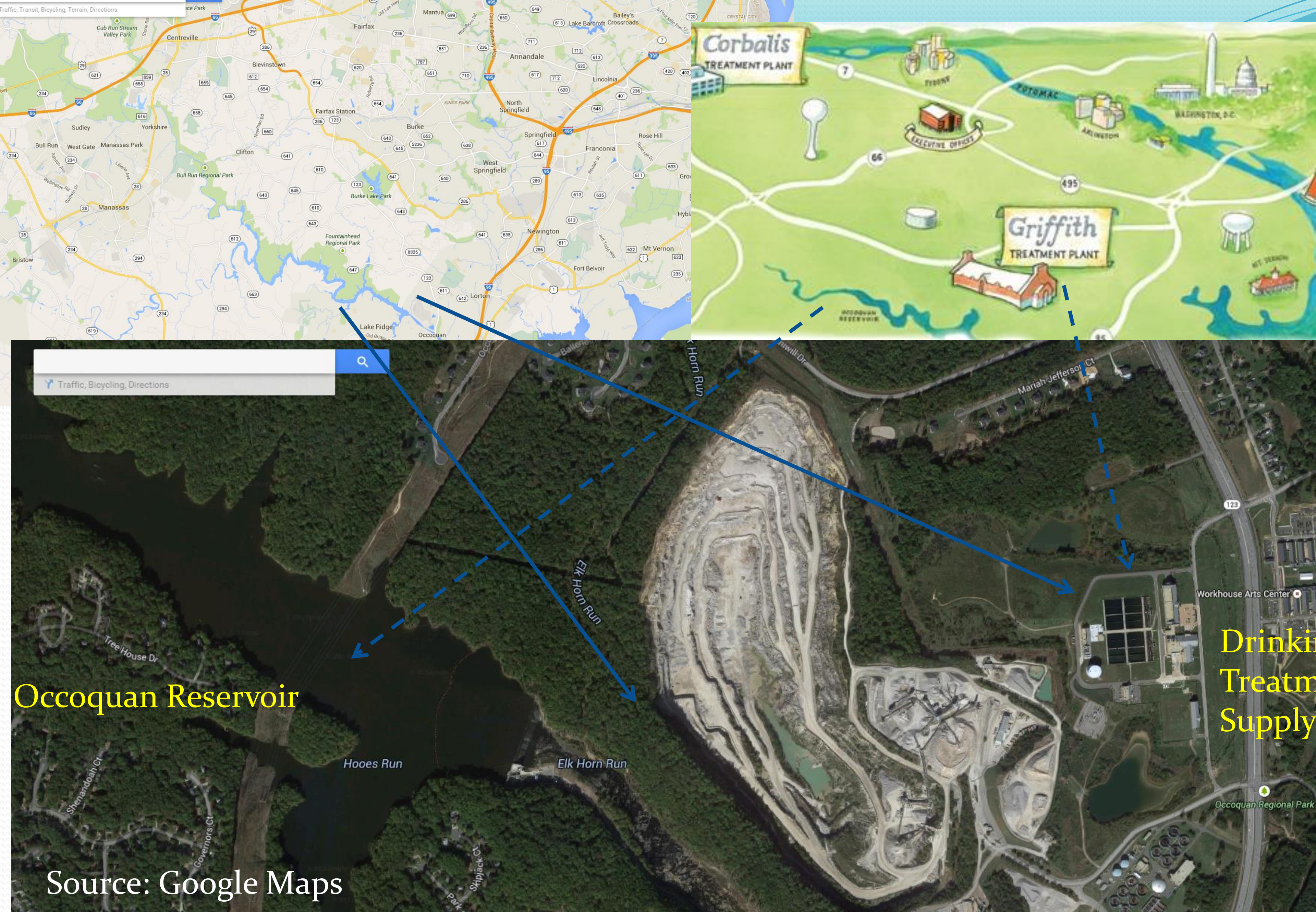
UOSA



UOSA Advanced
Wastewater Treatment and Water Purification Plant

Advanced Water Purification plant has Carbon Adsorption Towers (Adsorb organics)

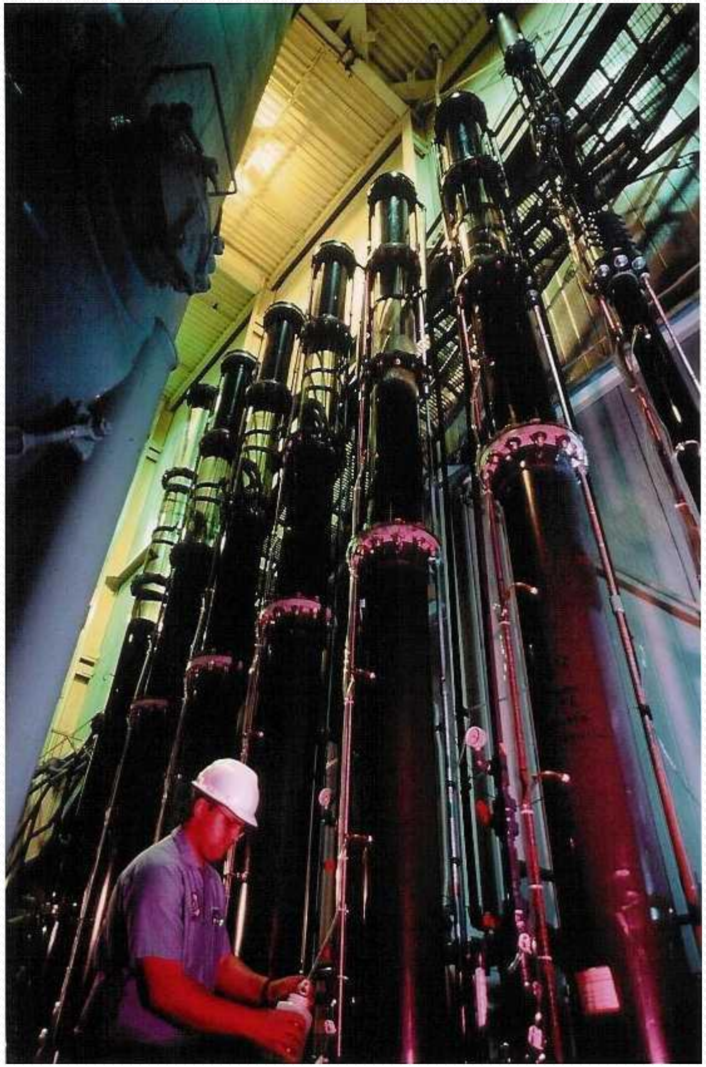
Water travels through 12 miles of Bull Run river and then through Occoquan drinking water reservoir


Corbalis
TREATMENT PLANT
Griffith
TREATMENT PLANT
Occoquan Reservoir
Hooes Run
Elk Horn Run
Workhouse Arts Center
Occoquan Regional Park
Drinki
Treatm
Supply
Source: Google Maps

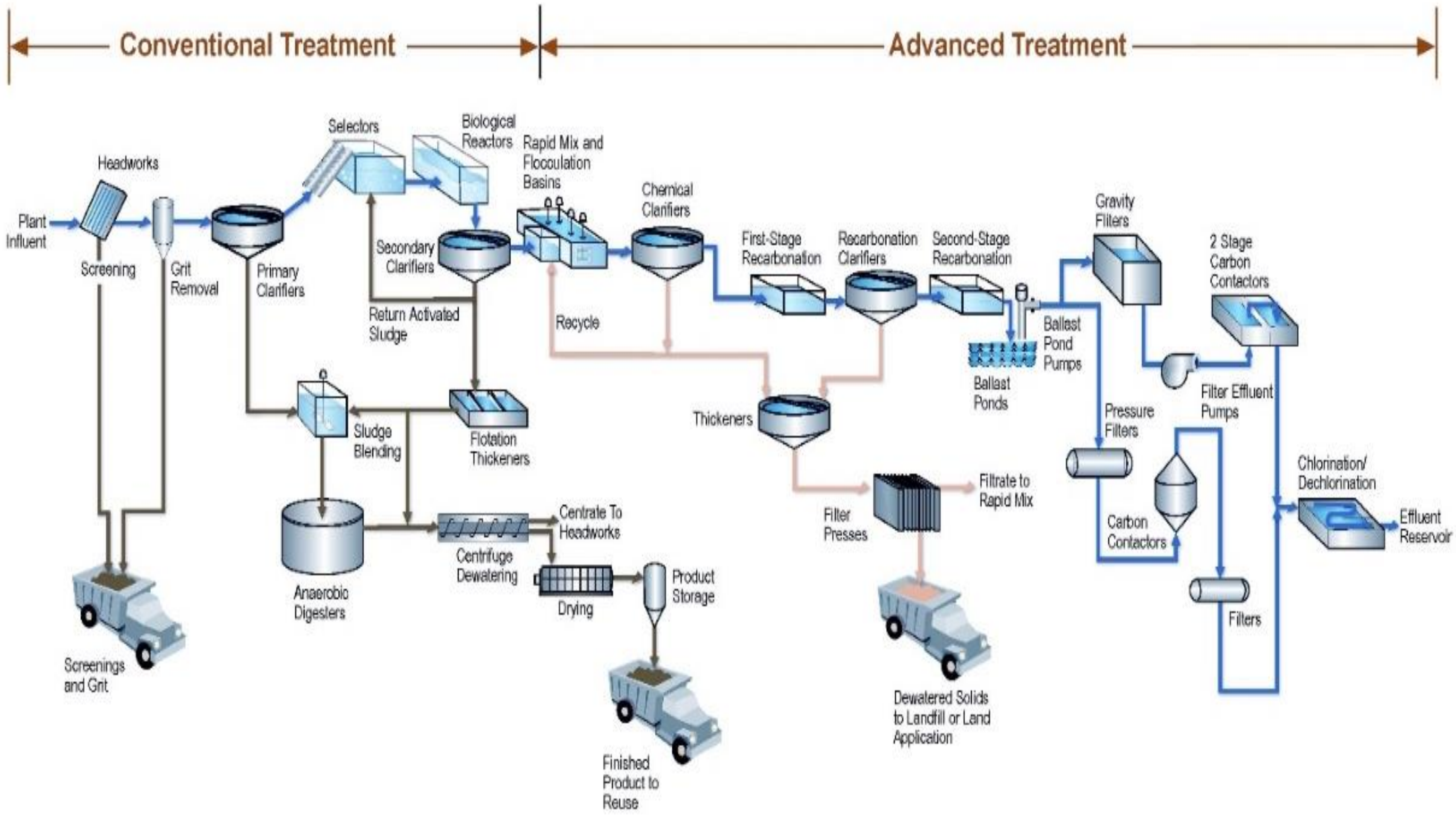
UOSA

GAC Regeneration Furnace

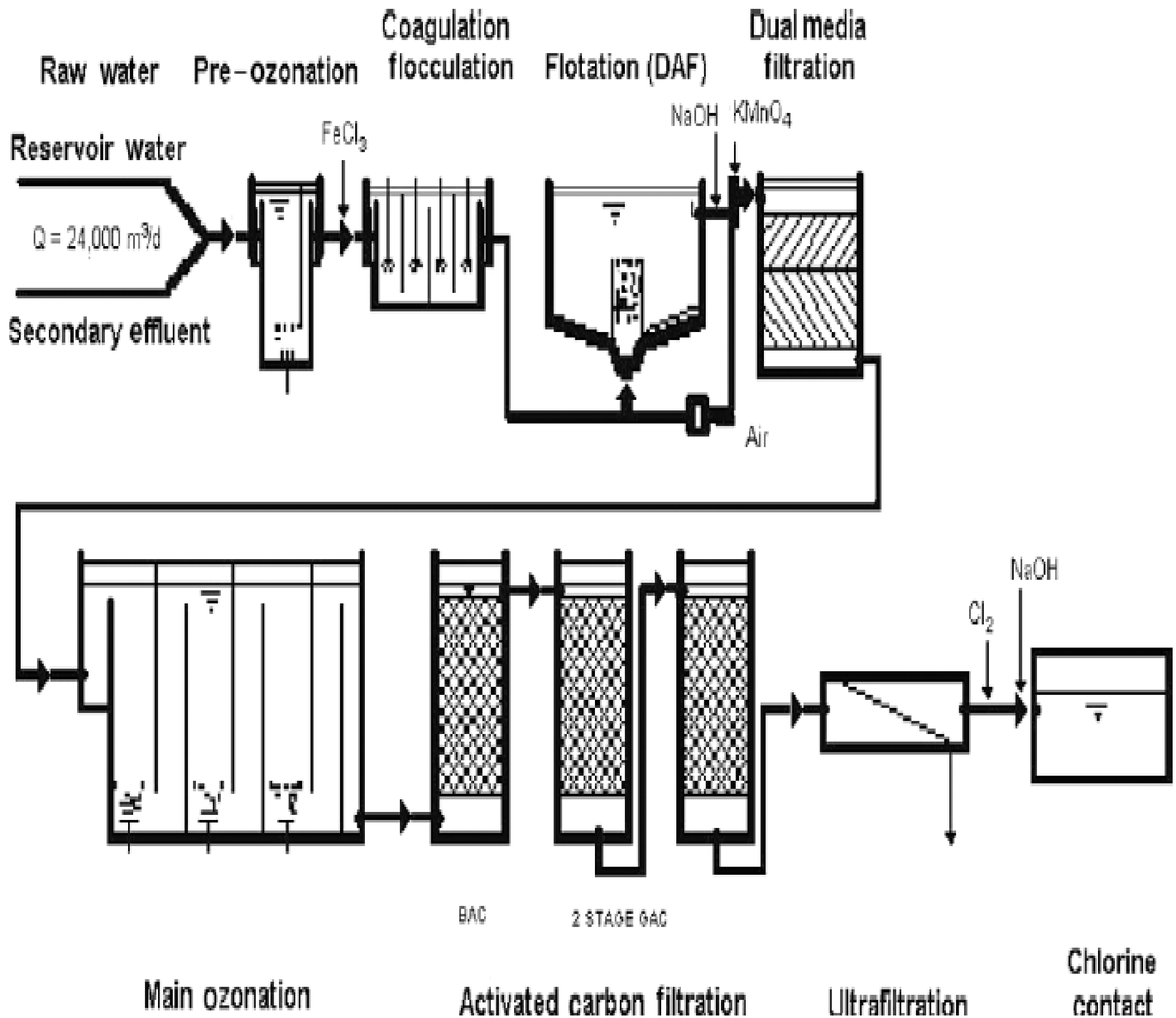
Carbon Contactor Pilot



Upper Occoquan Service Authority, VA Reservoir Augmentation IPR

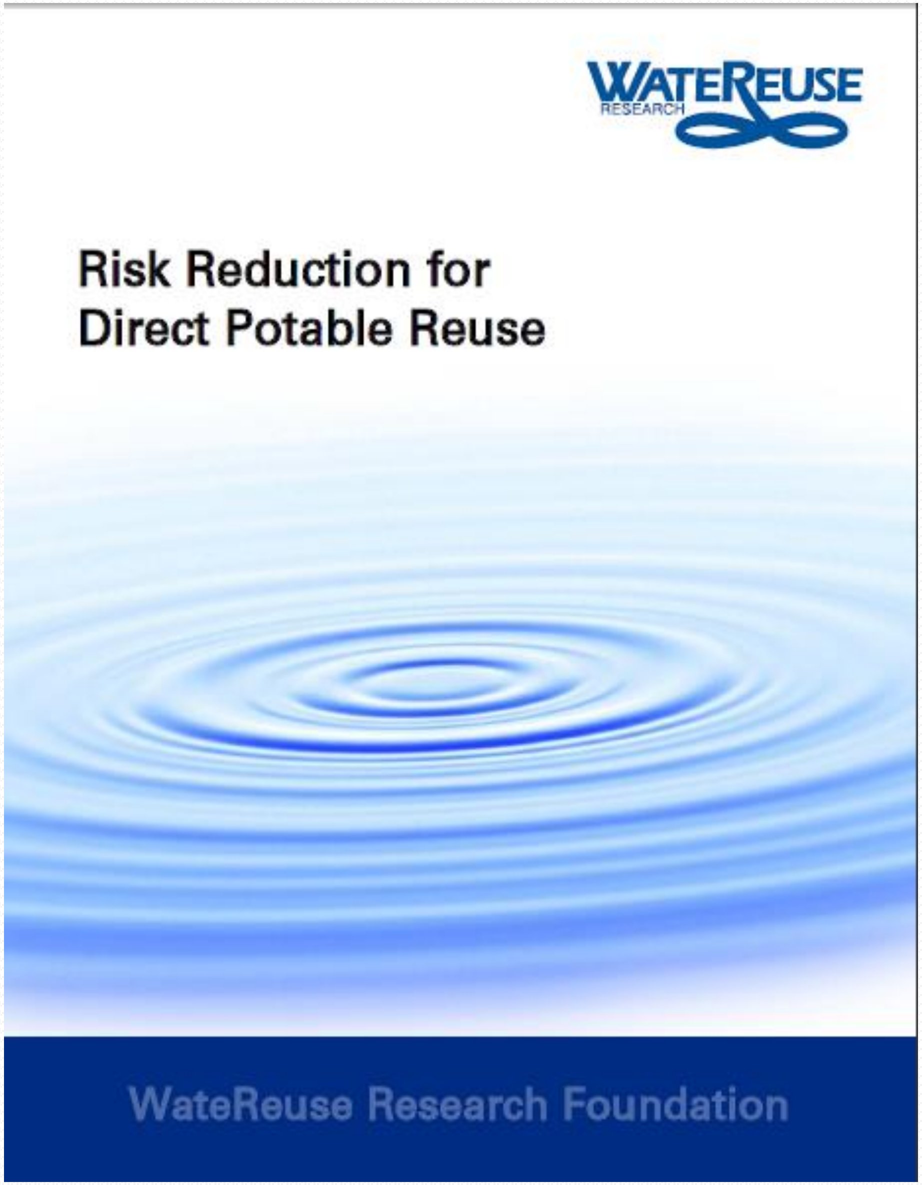


Windhoek, Namibia- Pipe to Pipe DPR



Research Tells Us to Eliminate the Acute Risk and Minimize the Chronic Risk

- Pathogen Removal
  - 12-log virus
  - 9-log bacteria
  - 10-log protozoa



Reference:
Andrew Salveson, Carollo
WEFTEC 2016, W13
Moving from Conventional
Treatment to Potable Reuses

Chronic Risk and Public Perception Are Also Important

DBPs	Criterion
THMs	
HAA5	
NDMA	
Bromate	
Chlorate	

Pharmaceuticals	Criterion[a]/If Applicable
Cotinine/Primido Phenyltoin	
Meprobamate/Ate	
Carbamazepine	
Estrone	

Chemicals Relevant to Public Health	Criterion/ If Applicable
PFOA	0.4 µg/L
PFOS	
Perchlorate	
1,4-Dioxane	

Steroid Hormones	Criterion/ If Applicable
Ethinyl Estradiol	None, but if established, it will
17-β-E	

Other Chemicals	
Sucralose	150 mg/L[c]
TCEP	5 µg/L
DEET	200 µg/L
Triclosan	2,100 µg/L

Reference:
Andrew Salveson, Carollo
WEFTEC 2016, W13
Moving from Conventional Treatment to Potable Reuses

UV Dose in CA Potable Reuse Dictated by Trace Organic Destruction Targets

- NDMA
  - DBP formed in Water and Wastewater Treatment
  - CA DDW Notification Level of 10 ppt
  - Often 1-log to 2-log removal required through advanced treatment
  - UV most effective technology for destruction
- 1,4-dioxane
  - Reduction of 0.5 log required by CA DDW as a surrogate for wide ranging trace pollutants
  - Needs AOP for destruction
  - Oxidant addition required to attain AOP with UV

WEFTEC 2016, W13
Moving from Conventional Treatment to Potable Reuses
Andrew Salveson, Carollo

Learn to Manage the Higher Risk Associated with Reuse

- Operations, Maintenance, Management and Engineering have to
  - Understand Risk
  - Develop rational tools

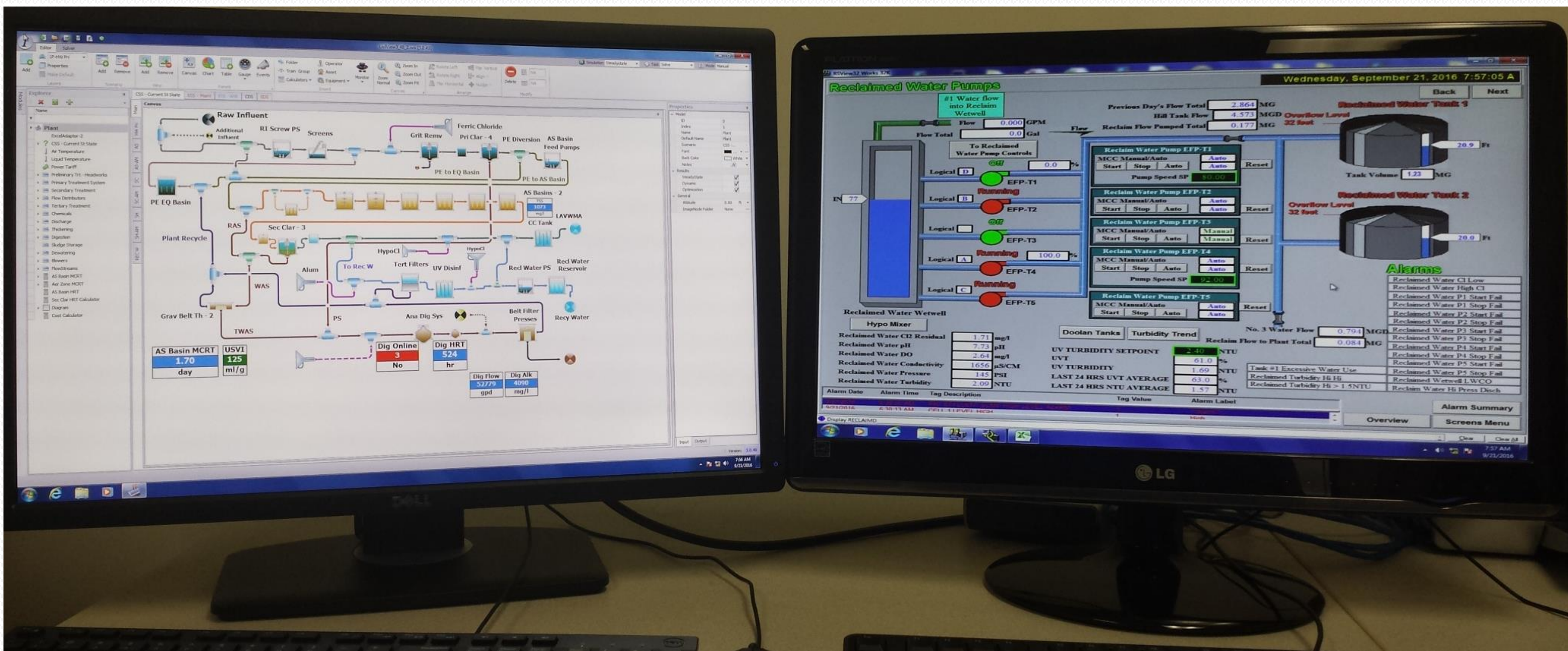
What does <u>not</u> help:

- 200+ sensors is not the answer
  - No plant can manage them over time
  - You operate with a manageable number sensors

What is helpful:

- Implementing an Artificial Intelligence Platform
- Strategic use of storage and buffers
- Managing operations to Laboratory capabalities and turnaround times

Livermore, CA – moving to AI Platform



Moving Wastewater Systems towards Economic and Sustainable Reuse
Part IV

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Outline

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Major Financial and Environmental Costs and Associated Considerations for 20 mgd Plant Capacity

Scenario	Capital Cost (millions)	Annual O&M Cost (millions)	Annual Environmental Cost (millions)	Total TBL NPV (millions)	Power Consumption (MWh/year)	Chemical Consumption (dry tons/year)	Air Emissions (tons/year)	
							CO_2	Other
Nonpotable Reuse for Landscape Irrigation								
S1A (GMF-Cl_2)	$32	$2.1	$0.17	$72	1,800	190	1,200	4.5
S1B (MF-Cl_2)	$47	$2.8	$0.2	$101	2,200	230	1,900	5.2
S1C (MF-RO-Cl_2)	$101	$5.5	$1.4	$233	13,300	1,900	11,800	34
Potable Reuse for Reservoir Augmentation								
S2A (Coag-Sed-O_3-BAC-GAC-UV)	$91	$4.2	$0.4	$173	4,400	1,770	2,900	11
S2B (MF-RO-UVAOP) with Ocean Disposal of Concentrate	$120	$5.9	$1.6	$267	16,000	1,860	13,400	30
S2B (MF-RO-UVAOP) with Mech Evaporation of Concentrate	$172	$10.9	$6.3	$533	65,400	3,020	44,200	150
S2B (MF-RO-UVAOP) with Evaporation Ponds for concentrate	$303	$9.0	$2.2	$512	22,000	1,860	17,200	49

BAC = Biological Activated Carbon filtration; Cl2 = Chlorine Disinfection; GAC = Granular Activated Carbon; GMF = granular media filtration; MF = Microfiltration;

Cost of Overtreating Reclaimed Water, (Schimoller and Kelly, WRRF 10-01, 2014)

35% Lower

Developing a Strategy

Photo Courtesy of Roger Snyder
Virginia Tech, UOSA, Occoquan Reservoir

What is the “TDS target” for water supply?

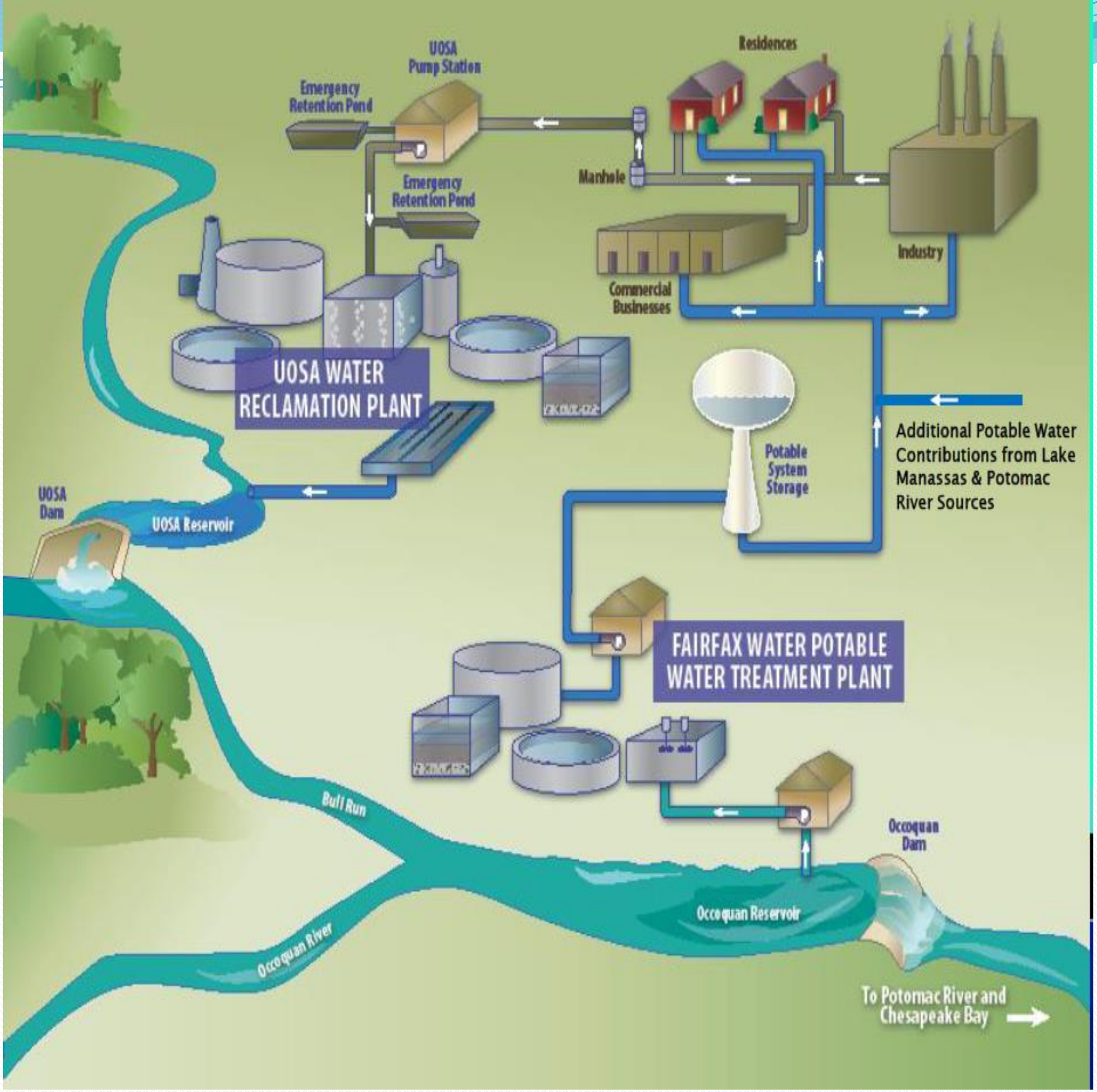
- What is your “limit” on TDS in the water supply?
  - TDS is a secondary limit – aesthetic quality
  - Federal Secondary Standard - 500 mg/L
  - Some states target 1000 mg/L
  - Outside the US, the target may be 1000 to 2000 mg/L

- Should you go for the lower cost option if your blended finished water, with recycled water component, stays below the local standards?

Where are you starting from?

- What is the range of TDS in your raw, unblended supply?
- What is the range of TDS going to be in the finished potable reuse product, (i.e. the reclaimed wastewater component)?
- What is your anticipated range for blend ratios?
- What is your target acceptable criterion for TDS in the blended potable water sent out to distribution?

Understand Change in TDS from Drinking Water to Water blended with Recycled Water

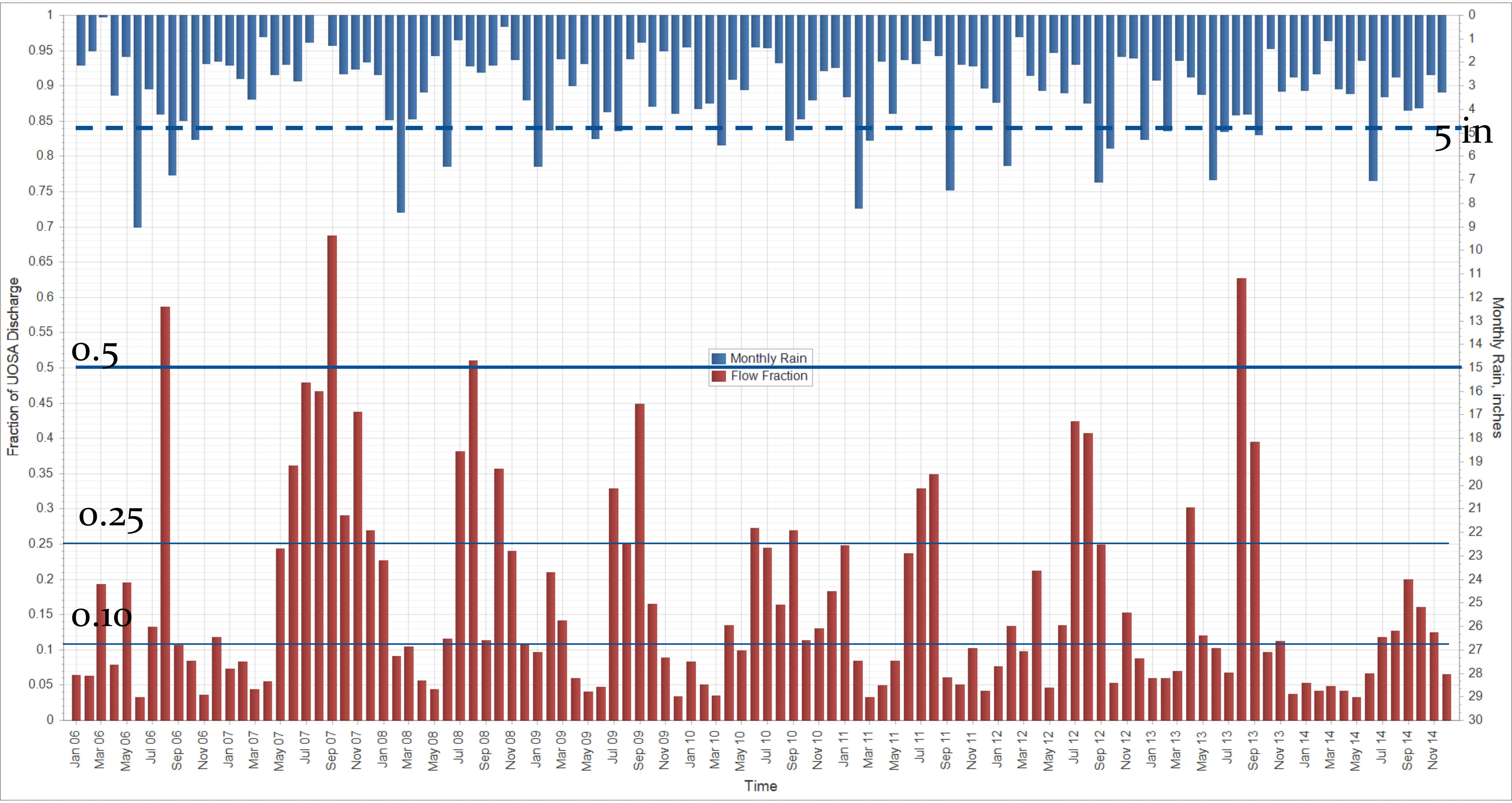


UOSA Discharge as a Fraction of Stream Flow

Monthly Totals

Fraction of Discharge from UOSA

Monthly Rainfall



Source Water TDS Variability: West and SW - Less rainfall (10 to 15 inches)

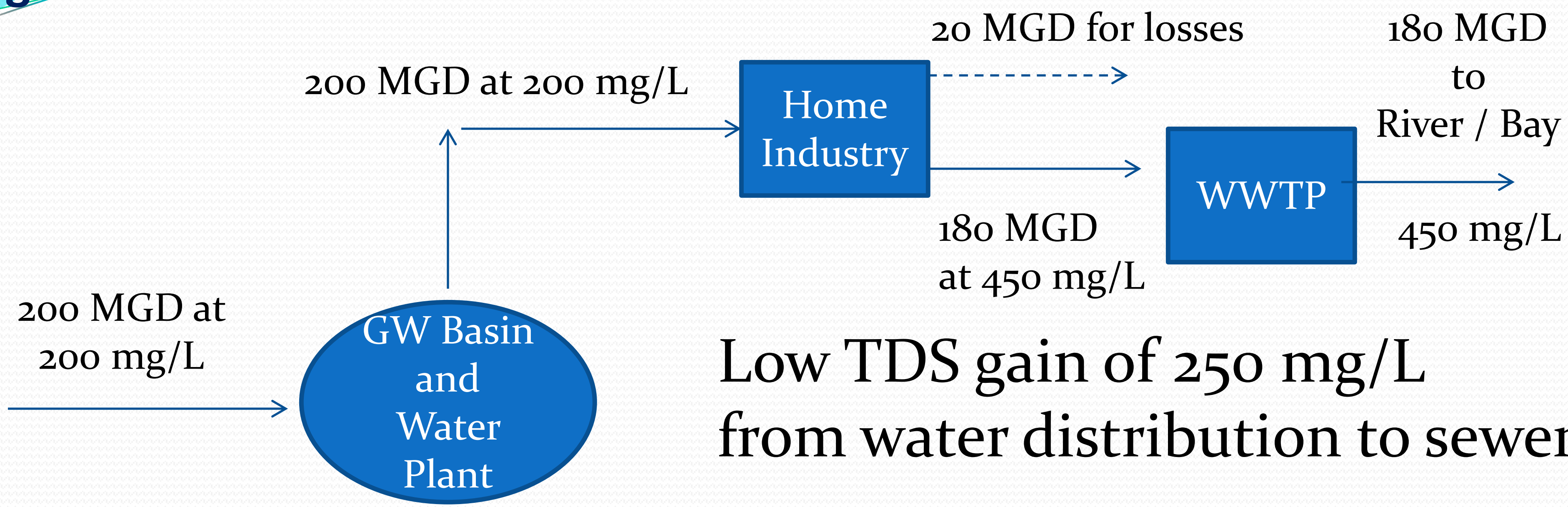
Water Supply	Source	Year 2001 Supply[1]		TDS Concentration (mg/L)	
		AFY	Percent	Year 2001	Historical Average 1975-1999
Imported Supply	Colorado River	437,750	64%	560[2]	700[4]
	SWP	159,700	24%	290[3]	250[4]
Local Supply	Surface Water	51,400	8%	300 – 1200[5]	300 – 1200[5]
	Groundwater	12,700	2%	400 – 700[6]	400 – 700[6]
	Desalted Groundwater	5,500	1%	400[7]	400[7]
	Recycled Water	12,700	2%	800 – 1100[8]	800 – 1100[8]

What questions should you ask regarding the TDS?

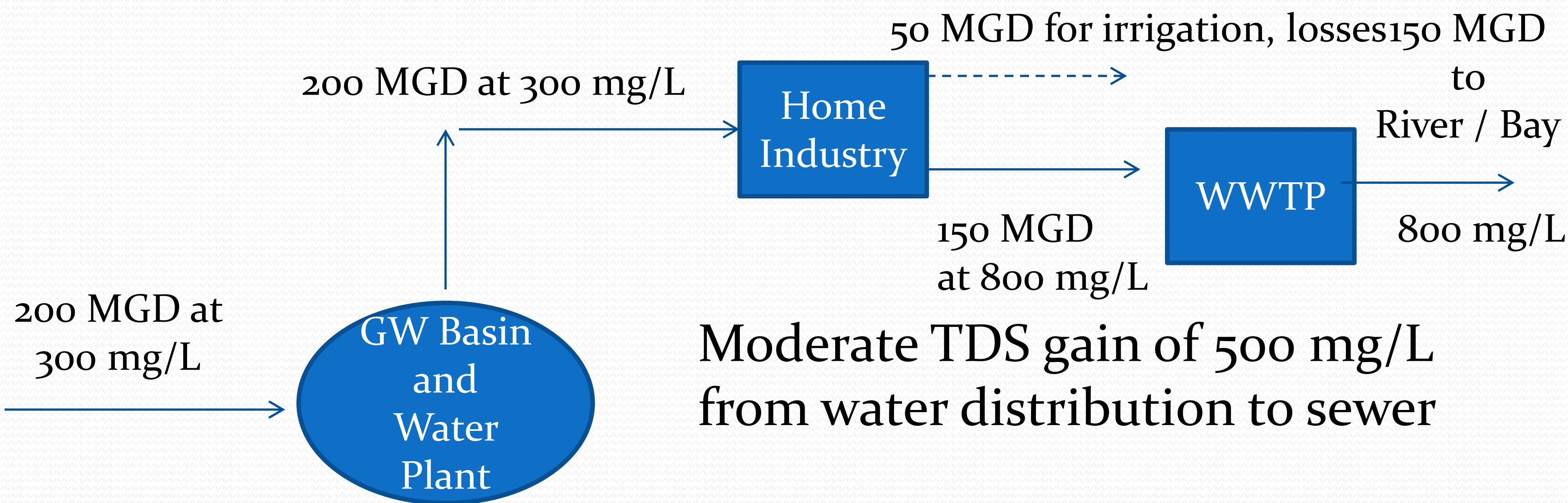
- What is the TDS of your Raw Water Supply?
  - Normal year
  - Drought
- What is the TDS gain from supply to recycled water?
  - May change in different years
  - May change with water conservation
- What is the strategy for blending raw water & recycled water?
  - Proportion of Raw Water to recycled water
  - Does it vary in different parts of the distribution system

Two Scenarios with regard to TDS levels in water & wastewater

Figures shows TDS Mass balance before Reuse



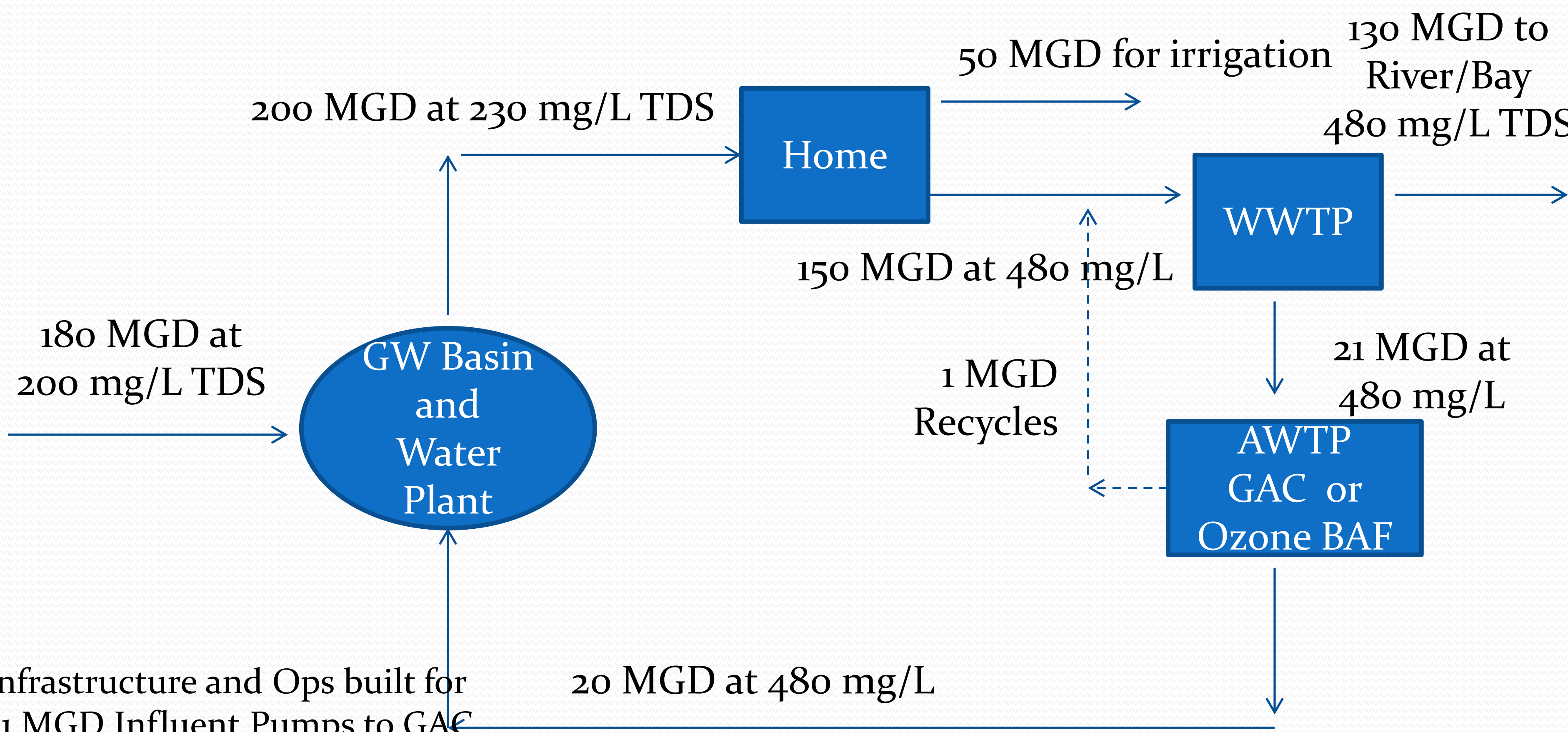
Low TDS gain of 250 mg/L from water distribution to sewer



Moderate TDS gain of 500 mg/L from water distribution to sewer

Mass Balance for Low TDS with GAC or Ozone BAF and 10% Reuse

Allows Drinking Water TDS to increase but keeps it below 500 mg/L

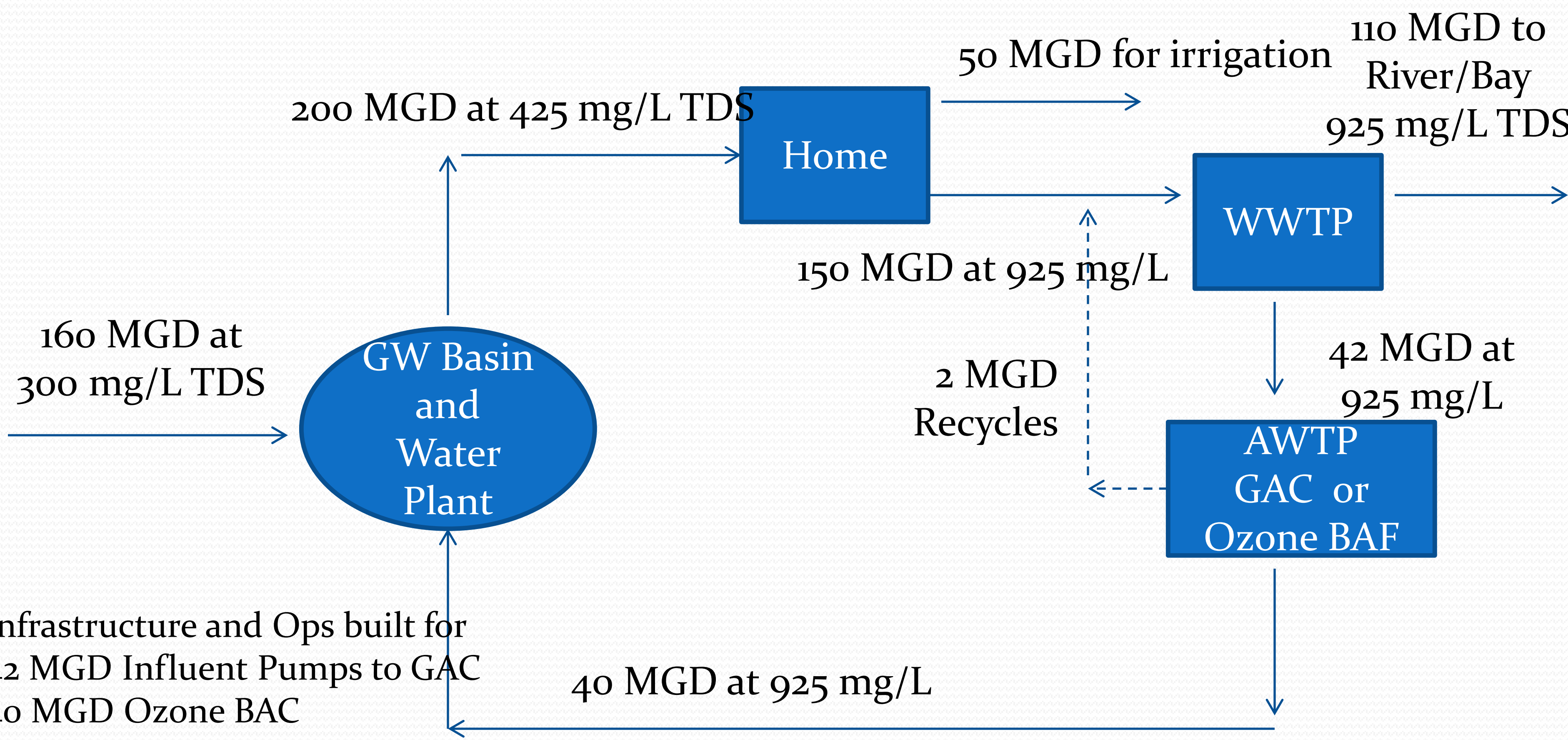


Infrastructure and Ops built for
21 MGD Influent Pumps to GAC
20 MGD Ozone BAF

TDS gain is 14% with the water recycling.
Note that drinking water supply TDS is 230 mg/L, well below 500 mg/L

Mass Balance for Moderate TDS with GAC or Ozone BAF and 20% Reuse

Allows Drinking Water TDS to increase but below 500 mg/L

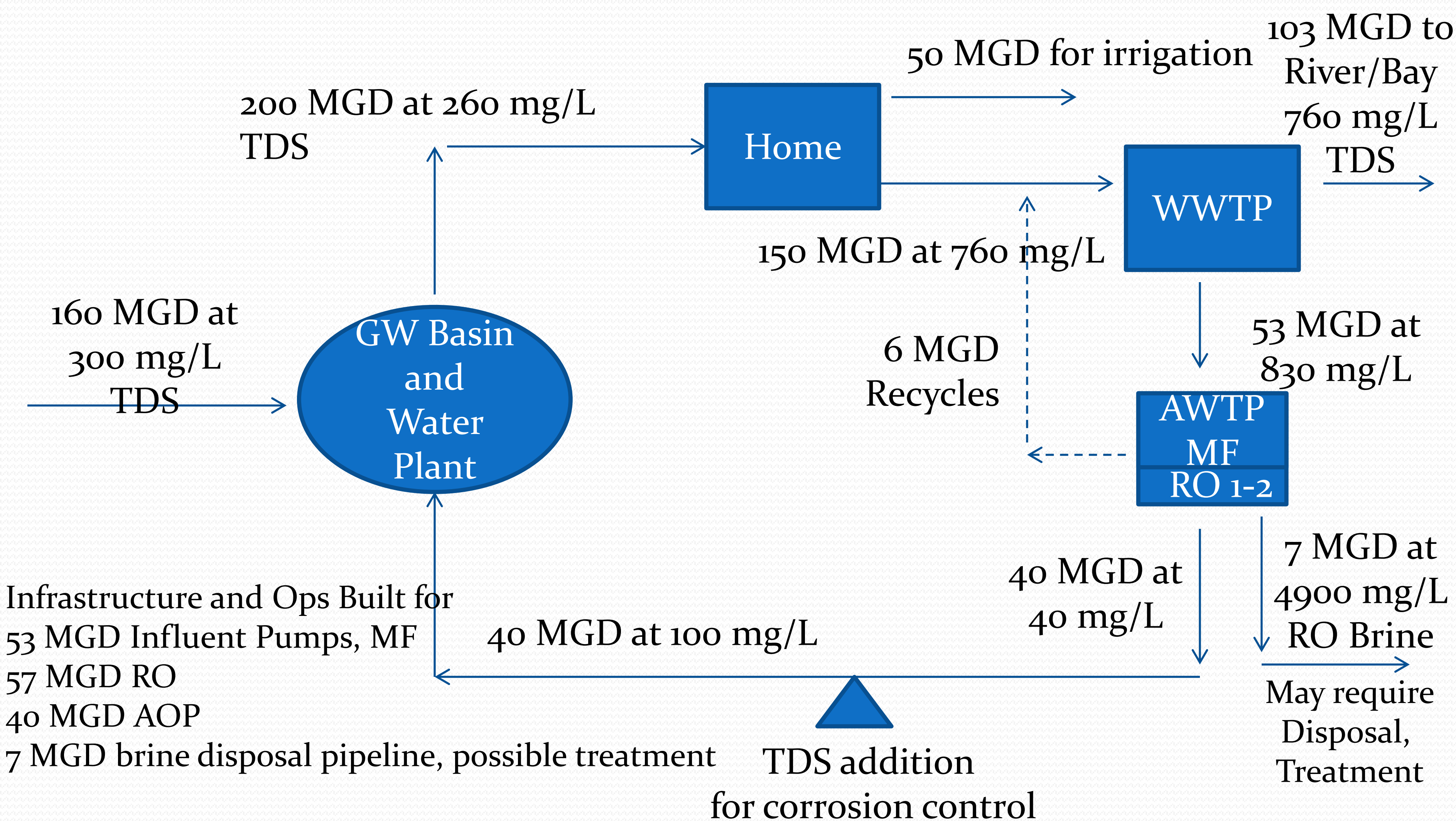


Infrastructure and Ops built for
42 MGD Influent Pumps to GAC
40 MGD Ozone BAC

TDS gain is 42% with the water recycling.

Note that drinking water supply TDS is 425 mg/L, just below 500 mg/L

Mass Balance for Moderate TDS gain
2 Stage RO and 20% Reuse
All Recycled Water Through RO



Comparison at 20% reuse in Water Supply

GAC /BAF Based for Moderate TDS Gain between water supply and sewer

Typically 200 to 500 mg/L

- Increases TDS
  - From 300 to 425 mg/L
  - Similar to drought impact on river water source
  - 42% increase in TDS
- No brine to dispose
- Precaution
  - If TDS of water supply exceeds 400 mg/L, consider RO system on part of source water or reuse water

How do we reconfigure if we want to limit the TDS increase?

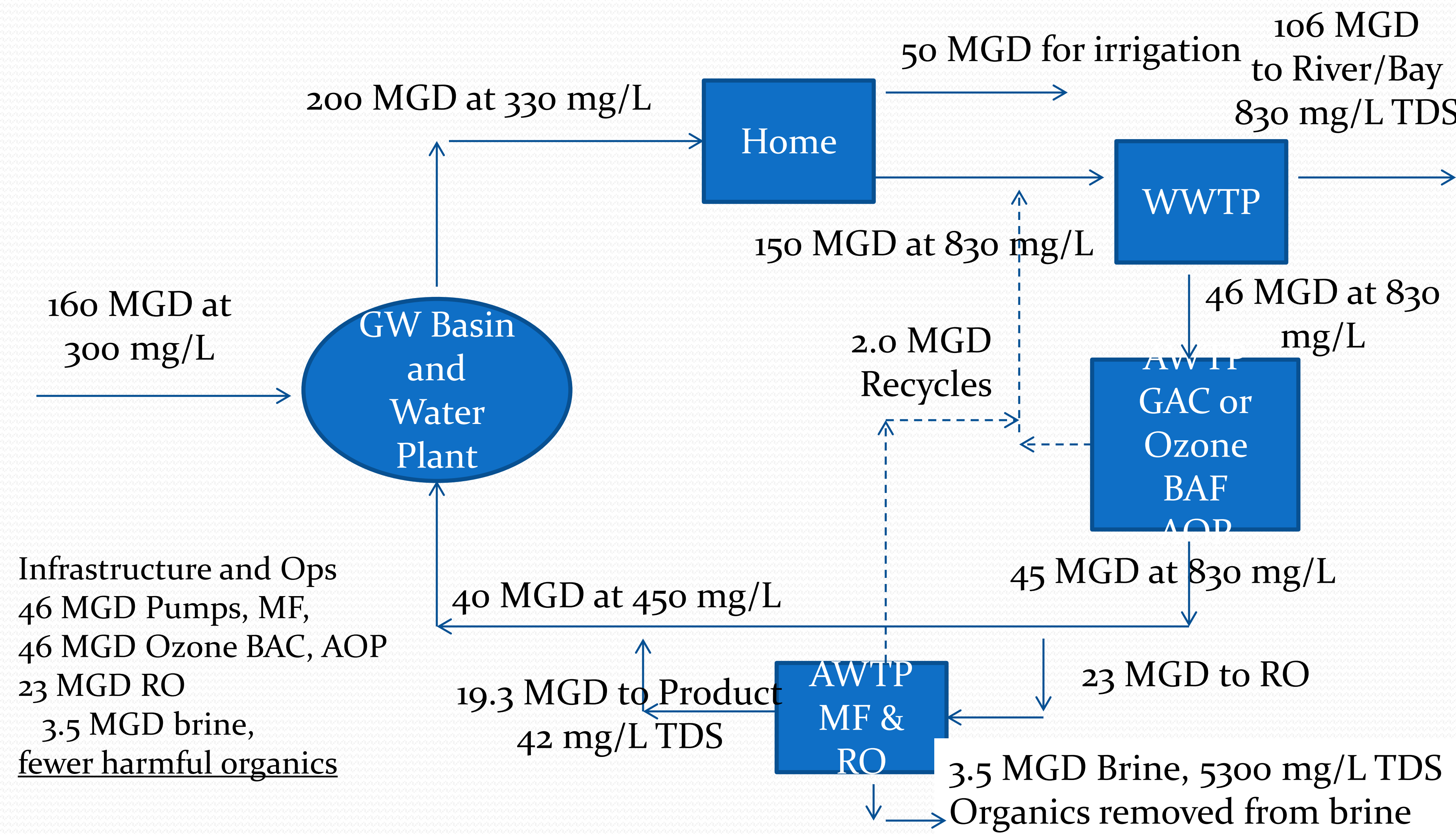
RO Based – Appropriate when there is a high TDS Gain between water supply and sewer

Typically 500+ mg/L

- Reduces TDS of water supply
  - From 300 to 260 mg/L
- Good alternative for
  - Diluting effect of salt water intrusion
  - Groundwater recharge with TDS below other water sources
- Precaution
  - If existing NPDES or outfall cannot be used, have to bear cost and understand sustainability of brine disposal

How do we reconfigure if we want to remove organics in brine?

Developing Cost Effective Hybrid Solution (Side stream RO) for Moderate TDS with GAC or Ozone BAF,
20 % Reuse with Small RO to limit TDS increase to 10%



Recommended Approach

Select the most economic system for Water Reuse based on sufficient analysis and understanding of local conditions

- MF-RO-AOP is a good fit when
  - There is a high increase in TDS (> 500 mg/L) from water distribution to sewer system and higher reuse component in blend
  - One may depend principally on reuse water for extended periods, such as 10 consecutive years , with high peaks or recycle ratios because of:
    - Limited Reservoir volume
    - Limited imported water
    - Limited blending
  - Deep sea brine disposal or use of existing NPDES permit
    - If disposal or cost is a challenge, consider hybrid solution

- GAC-AOP or Ozone BAF AOP is a good fit when
  - There is a moderate (200 to 500 mg/L) increase in TDS from water distribution to sewer system and lower reuse component in blend
    - Capital costs can be 10 -25% lower
    - 20 yr Life cycle TBL costs may be 35% lower
- TDS may go up 25 - 40 percent for a higher mix (i.e. 20% reuse 80% other supplies)
  - However, may keep TDS of supply as low as 350 mg/L

GAC or Oz-BAF to treat brine
Then consider side stream RO

Hybrid Solutions with RO treatment of portion of reuse can be used to limit

Optimize Sizing & Operation of Engineered Buffers and Storage – can it save another 10%?