1

Water Reuse: Where Are We Now, and What Is the Future?

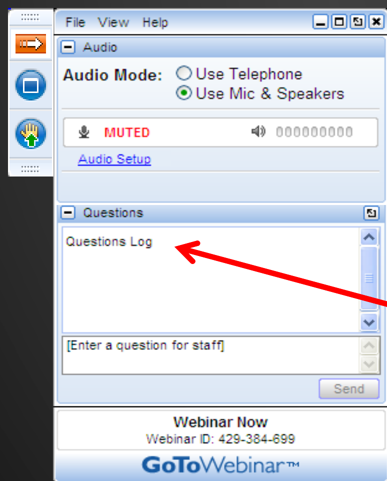
Thursday March 21, 2019

1:00 – 3:00 PM ET

Water Environment Federation
the water quality people®

2

How to Participate Today

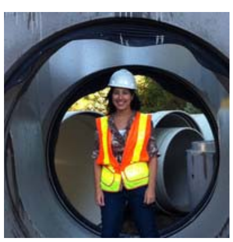


- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

Water Environment Federation
the water quality people

3

Today's Moderators



- Eileen Navarrete
  - Construction Projects Administrator
  - City of Raleigh Public Utilities
- Tania Datta
  - Assistant Professor, Civil & Environmental Engineering

Raleigh

Tennessee TECH

Water Environment Federation
the water quality people

4

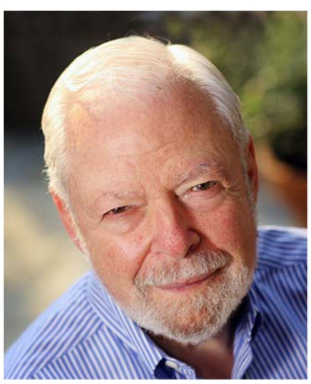
Today's Speakers

- George Tchobanoglous
  - Introduction to Potable Reuse
- Bahman Sheikh
  - Current and Future Role of Non-potable Reuse
- Germano Salazar-Benites
  - HRSD's SWIFT Project

Water Environment Federation
the water quality people

5

Our Next Speaker



George Tchobanoglous
Professor Emeritus
Department of Civil and Environmental Engineering
University of California, Davis

Water Environment Federation
the water quality people

6

INTRODUCTION TO POTABLE REUSE

7

DISCUSSION TOPICS

- Paradigm shift in view of wastewater
- Overview of is potable reuse
- What are the driving forces for IPR and DPR
- Where does potable reuse fit in the water portfolio
- Key components of an IPR or DPR program
- Regulatory concerns with potable reuse
- A different focus for wastewater treatment
- Comprehensive source control for potable reuse
- Closing thoughts

8

PARADIGM SHIFT IN VIEW OF WASTEWATER FOR THE 21ST CENTURY

Wastewater is a renewable recoverable source of potable water, resources, and energy

9

OVERVIEW OF POTABLE REUSE?

- What are the different types of potable reuse?
  - ✓ *de facto* indirect potable reuse (*df*-IPR)
  - ✓ Indirect potable reuse (IPR)
  - ✓ Direct potable reuse (DPR)
- Technologies for IPR and DPR?
- What are the cost and energy implications?
- Examples of IPR and DPR

Water Environment Federation the water quality people

10

DE FACTO INDIRECT POTABLE REUSE

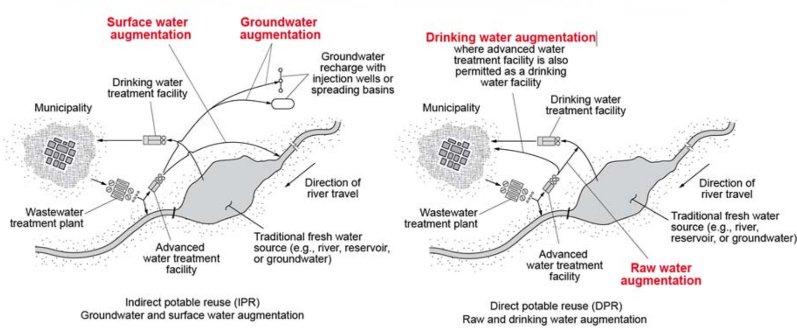
The downstream use of surface water as a source of drinking water that is subject to upstream wastewater discharges.

Courtesy City of San Diego

Water Environment Federation
the water quality people

11

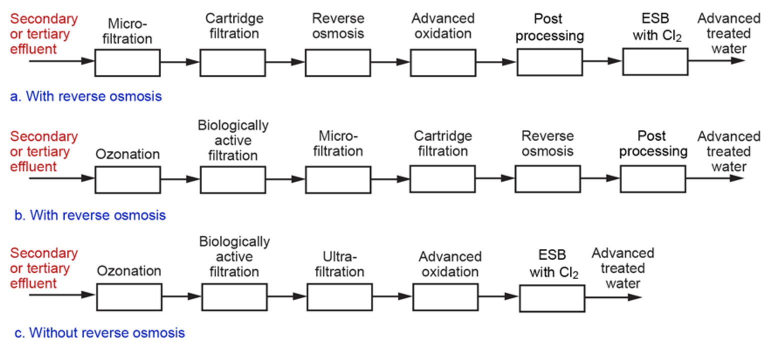
INDIRECT AND DIRECT POTABLE REUSE



Water Environment Federation
the water quality people

12

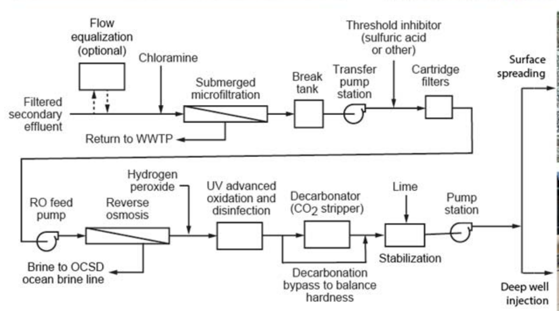
TECHNOLOGIES FOR POTABLE REUSE

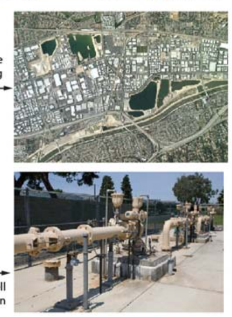


TECHNOLOGY IS NOT A LIMITING CONSTRAINT!!

13

ORANGE COUNTY WATER DISTRICT





14

Microfiltration, Cartridge Filters, Reverse Osmosis, and Advanced Oxidation (UV) Technologies at OCWD

15

ONGOING RESEARCH AT OCWD
TESTING OF NEW MEMBRANE MODULES

16

DECARONATION AND LIME SATURATION AT OCWD

Water Environment Federation the water quality people

17

WHAT DOES DPR COST?

Supply option	Cost, \$/10³ gal (\$/AF) Treatment	Residuals management	RO concentrate management	Conveyance facilities
ATW with RO	2.10 – 2.76 ([illegible]900)	0.03 – 0.15 (10 – 50)	0.21 – 2.38 (70 – 775)	0.31 – 3.07 (100 – 1,000)
ATW without RO	1.23 – 2.15 (400 –700)	0.03 – 0.15 (10 – 50)	n.a.	0.31 – 3.07 (100 – 1,000)
Brackish groundwater desalination (inland)	2.76 – 3.84 (900 – 1,250)	0.06 – 0.31 (20 – 100)	0.21 – 2.15 (70 – 700)	0.92 – 6.14 (300 – 2,000)
Seawater desalination	5.52 – 6.44 (1,800 – 2,100)	0.06 – 0.31 (20 – 100)	0.31 – 0.61 (100 – 200)	1.23 – 9.21 (400 – 3,000)
Retail cost of treated imported surface water	1.23 – 3.99 (400 – 1,300)		n.a.	0.31 – 1.84 (100 – 600)
Water use efficiency, conservation, and use restrictions	1.38 – 2.92 (450 – 950)			0.31 – 1 .23 (100 – 400)

Note: \$/10³ gal x 325.89 = \$/AF

Water Environment Federation the water quality people

18

DPR ENERGY USAGE

Technology/water source	Energy required: Range, kWh/10^3 gal	Energy required: Typical, kWh/10^3 gal	Energy required: Typical, kWh/m^3	Carbon footprint kg CO_{2e}/10^3 gal
Secondary treatment without nutrient removal	1.35 – 1.05	1.25	0.33	0.63
Tertiary treatment with nutrient removal effluent filtration	1.95 – 1.60	1.85	0.49	0.93
Advanced water treatment	3.25 – 3.50	[illegible]	0.87	1.65
Ocean desalination	9.50 – 14.75	12.00	3.17	6.00
Brackish water desalination	3.10 – 6.20	5.85	1.55	2.93
Interbasin transfer of water, California State Water Project	7.92 – 9.92	9.20	2.43	4.60
Interbasin transfer of water, Colorado River water	6.15 – 7.40	6.15	1.62	3.07
Conventional water treatment	0.30 – 0.40	0.37	0.10	0.19
Membrane-based water treatment	1.00 -1.50	1.25	0.33	0.63

Note: kWh/10^3 gal x 325.89 = kWh/AF

Water Environment Federation
the water quality people

19

WHERE DOES POTABLE REUSE FIT IN THE WATER PORTFOLIO?

WATER SOURCES
- Local surface water
- Local groundwater (shallow and deep)
- Imported water
- Potable reuse (DPR and IPR, potential 20 to 40%)
- Desalination (brackish and sea water)
- Stormwater (?)

OTHER MEASURES
- Centralized non-potable reuse (e.g., purple pipe)
- Decentralized non-potable reuse (e.g.,greywater)
- Conservation and curtailments

Water Environment Federation
the water quality people

20

Driving Forces for Indirect Potable Reuse

- The value of water will increase significantly in the future (and dramatically in some locations)
- De facto indirect potable reuse is largely unregulated (e.g., secondary effluent, ag runoff, urban stormwater, highway runoff)
- Infrastructure requirements limit reuse opportunities
- Existing and new technologies can and will meet the water quality challenge
- Population growth and global warming will lead to severe water shortages in many locations. A reliable alternative supply should be developed
- Stringent environmental regulations

Water Environment Federation
the water quality people

21

REPRESENTATIVE POTABLE REUSE PROJECTS

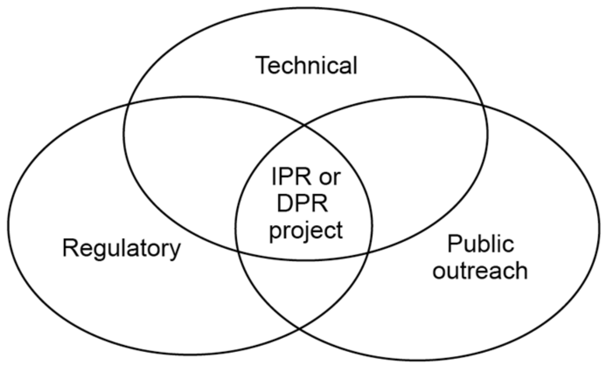
Project	Capacity, m^3/s	In operation since
Groundwater augmentation		
Montebello Forebay, Los Angeles County, California	2.35	1962
Orange County Water District, Ground Water Replenishment System (GWRS)	4.38	2008
West Basin, California, USA	0.55	1993
Surface water augmentation		
Gwinnett County, Georgia, USA	2.63	2000
Upper Occoquan Service authority, Virginia, USA	2.37	1978
San Diego, California, USA	1.31	2020 (?)
Singapore NEWater	0.36	2000
Raw water augmentation		
Big Spring, Texas, USA		
Village of Cloudcroft, New Mexico, USA		
Drinking water augmentation		
City of Windhoek, Namibia	0.24	1968
Pure Cycle Corporation, Colorado, USA	– [a]	1972 – 1980

[a] Individual single home unit

Water Environment Federation
the water quality people

22

KEY COMPONENTS OF A SUCCESSFUL IPR AND DPR WATER REUSE PROGRAM



23

REGULATORY CONCERNS WITH POTABLE REUSE

- *Chronic toxicity resulting from the presence of trace organic constituents*
- *Acute toxicity resulting from the presence of pathogenic microorganisms*

24

NATURAL AND SYNTHETIC TRACE CONSTITUENTS OF CONCERN RELATED TO CHRONIC TOXICITY IN POTABLE REUSE

Category	Examples
Endocrine disrupting compounds	Pharmaceuticals, dioxin and similar compounds, polychlorinated biphenyls, pesticides, plasticizers such as bisphenol A.
Food and food additives	Phytoestrogens, sucralose
Household chemicals	Bisphenol A (BPA), flame retardants
Industrial chemicals	1,4-dioxane, tetrachloroethane
Natural chemicals	17ß-esteadiol, geosmin, phytoestrogens,
Personal care products	Fragrances, hair dye, pigments, sunscreen ingredients, triclosan
Pesticides	Atrazine, diuron, fipronil, lindane
Pharmaceuticals and metabolites	Analgesics antibiotics, ethinyl estradiol
Transformation products	Bromoform, chloroform, N-nitroso dimethylamine (NDMA), trihalomethanes

Water Environment Federation
the water quality people

25

REMOVAL OF TRACE CONSTITUENTS RELATED TO CHRONIC TOXICITY WITH ADVANCED WATER TREAMENT PROCESSES IS WELL ESTABLISHED

The greater concern in public water supplies is acute toxicity

DEVELOPMENT OF PROBABILISTIC BASED REQUIRED LOG_{10} REDUCTION VALUES FOR POTABLE REUSE TO SATISFY PUBLIC HEALTH CONCERNS

Item	Enteric virus	Giardia	Cryptosporidium
Untreated wastewater maximum density	10^5 virus/L	10^5 cysts/L	10^4 oocysts/L
Tolerable drinking water density (TDWD)	2.2×10^{-7} virus/L	6.8×10^{-6} cysts /L	1.7×10^{-6} oocysts /L
Ratio of TDWD to wastewater density	2.2×10^{-12}	6.8×10^{-11}	1.7×10^{-10}
Required $\log_{10}$ reduction value	12	10	10

Water Environment Federation
the water quality people

26

LOG REMOVAL CREDITS FOR PATHOGENS

Process	Log reduction credit		
	Virus	*Giardia*	*Cryptosporidium*
Benchmark treatment processes			
Secondary treatment	2	2	2
MF/UF	0	4	4
RO	2	2	2
UV/H_2O_2	6	6	6
Water treatment	4	4	4
Total credit	14	18	18
Required credits	12	10	10
Additional log-removal values with other treatment processes			
Aquifer storage	6	0	0
Ozone	4	3	1
Cl_2 disinfection	4	2	0

Water Environment Federation
the water quality people

27

PATHOGEN REMOVAL VALUES FOR TREATMENT TRAINS

Process	Performance monitoring method	Log reduction		
		V	*G*	*C*
Total, treatment train 1				
Primary and secondary treatment	No existing method	1	0.	1
MF	Twice daily pressure decay testing	0	4.0	4.0
RO	Online TOC	1.5	1.5	1.5
UV AOP	Intensity sensors	6	6	6
ESB with free Cl_2, CT = 900 mg•min/L	Online Cl_2	6	3	0
Total, treatment train 1		13.5	14.5	11.5
Total, treatment train 2				
Primary and secondary treatment	No existing method	1	0.	1
Ozone (O_3), minimum CT = 1 mg•min/L	Online O_3^{i}	5	3	0
BAF	None	0	0	0
MF	Daily pressure decay testing	0	4.0	4.0
RO	Online TOC	1.5	1.5	1.5
UV (no AOP)	Intensity sensors	6	6	6
Total, treatment train 2		12.5	10.5	7.5
Total, treatment train 3				
Primary and secondary treatment	No existing method	1	0.	1
Ozone (O_3), minimum CT = 1 mg•min/L	Online O_3^{i}	5	3	0
BAF	None	0	0	0
UF	Twice daily pressure decay testing	1	4	4
UV AOP	Intensity sensors	6	6	6
ESB with free Cl_2, CT = 900 mg•min/L	Online Cl_2	6	3	0
Total, treatment train 3		18	16	10

Water Environment Federation
the water quality people

28

A DIFFERENT FOCUS FOR WASTEWATER TREATMENT FOR POTABLE REUSE

Water Environment Federation
the water quality people

29

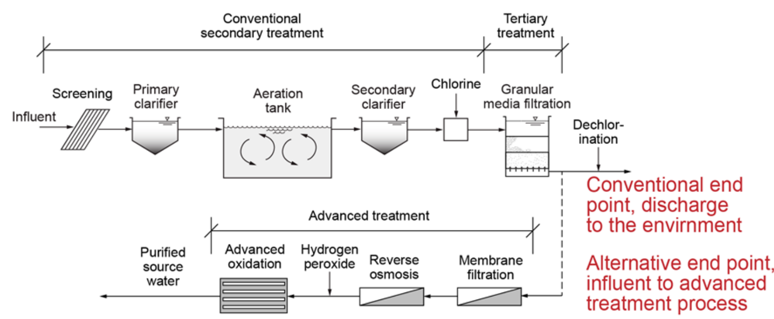
WATER QUALITY FOR POTABLE REUSE

WHERE TREATED WASTEWATER EFFLUENT IS TO BE USED FOR POTABLE REUSE, THE OBJECTIVE OF WASTEWATER TREATMENT SHOULD BE TO PRODUCE THE HIGHEST QUALITY EFFLUENT POSSIBLE FOR FURTHER TREATMENT FOR POTABLE REUSE

Water Environment Federation
the water quality people

30

OBJECTIVE AND FOCUS OF WASTEWATER TREATMENT FOR POTABLE REUSE IS DIFFERENT



Water Environment Federation the water quality people

31

DIFFERENCE BETWEEN CONVENTIONAL AND COMPREHENSIVE SOURCE CONTROL

Water Environment Federation the water quality people

32

SOURCE CONTROL FOR POTABLE REUSE

What two words describe
a source control program
for potable reuse?

33

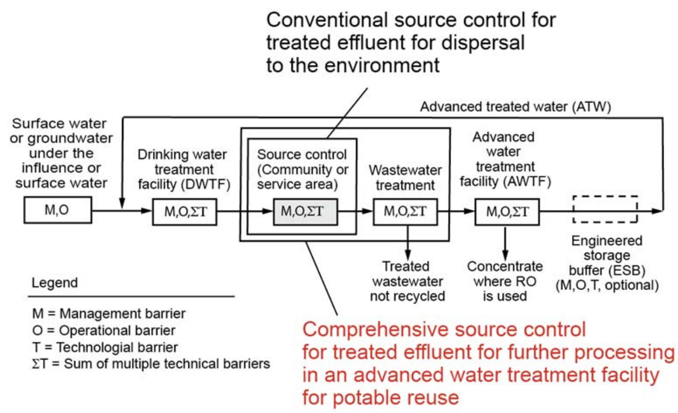
SOURCE CONTROL FOR POTABLE REUSE

What two words describe
a source control program
for potable reuse?

NO SURPRISES!

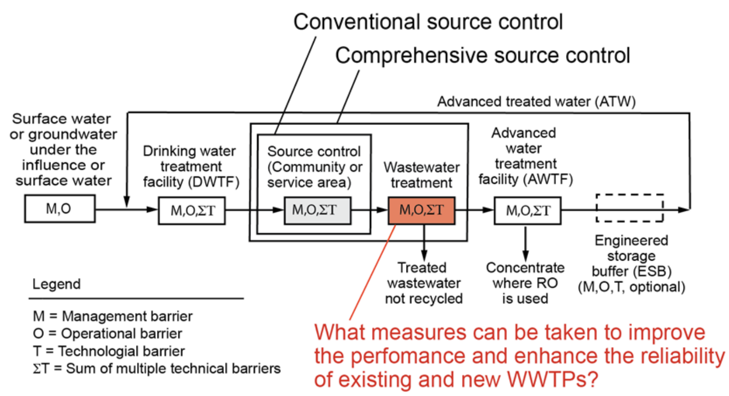
34

CONVENTIONAL AND COMPREHENSIVE SOURCE CONTROL FOR POTABLE REUSE



35

ACHIEVING ENHANCED WASTEWATER EFFLUENT WATER QUALITY FOR POTABLE REUSE



36

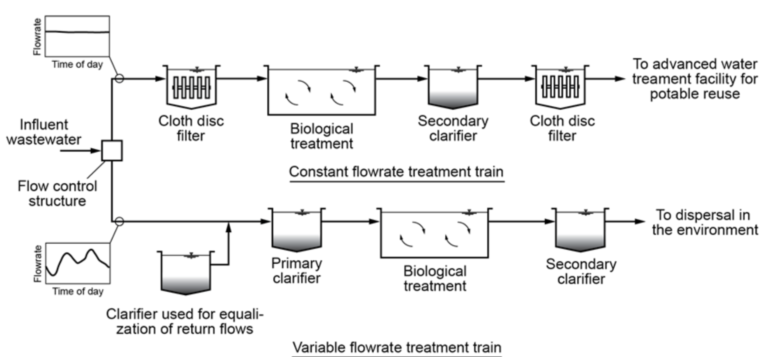
MEASURES TO IMPROVE PERFORMANCE AND ENHANCE RELIABILITY OF EXISTING AND NEW WWTPs

Measure	Effect of each measure
Proper assessment of impacts of water conservation	Efficiency, water quality, reliability
Enhanced preliminary treatment	Efficiency, reliability
Influent flow and load equalization	Efficiency, water quality, reliability
Enhanced primary treatment	Efficiency, water quality, reliability
Modify biological treatment process operational mode	Water quality, reliability
Implementation of new biological treatment process(es)	Water quality, reliability
Return flow equalization	Water quality
Return flow equalization and treatment	Water quality, reliability
Elimination of untreated return flows	Water quality, reliability
Divided treatment	Water quality, reliability
Effluent filtration and disinfection	Water quality, reliability
Improved process monitoring	Water quality, reliability

Water Environment Federation
the water quality people

37

DIVIDED TREATMENT FOR POTABLE REUSE WITH EXISTING WWTP



Water Environment Federation
the water quality people

38

CLOSING THOUGHTS

Ultimately, direct (and indirect) potable reuse is inevitable in urban and other areas and will represent an essential element of a sustainable water future

- Must think of wastewater differently
- Technology is not an issue
- The public is supportive
- To make it a reality, bold new planning must begin now!!

Water Environment Federation
the water quality people

39

THANK YOU FOR LISTENING and PARTICIPATING

Water Environment Federation
the water quality people

40

Our Next Speaker

Bahman Sheikh
Water Reuse Consultant
San Francisco, CA

www.bahmansheikh.com
bahman.sheikh@gmail.com

Water Environment Federation
the water quality people

41

Current And Future Role of Non-potable Reuse—Overview

- Evolution of Water Reuse Practice
- Limitations of Non-Potable Reuse
- Opportunities for Future Non-Potable Reuse
- Competition with Potable Reuse

Water Environment Federation
the water quality people

42

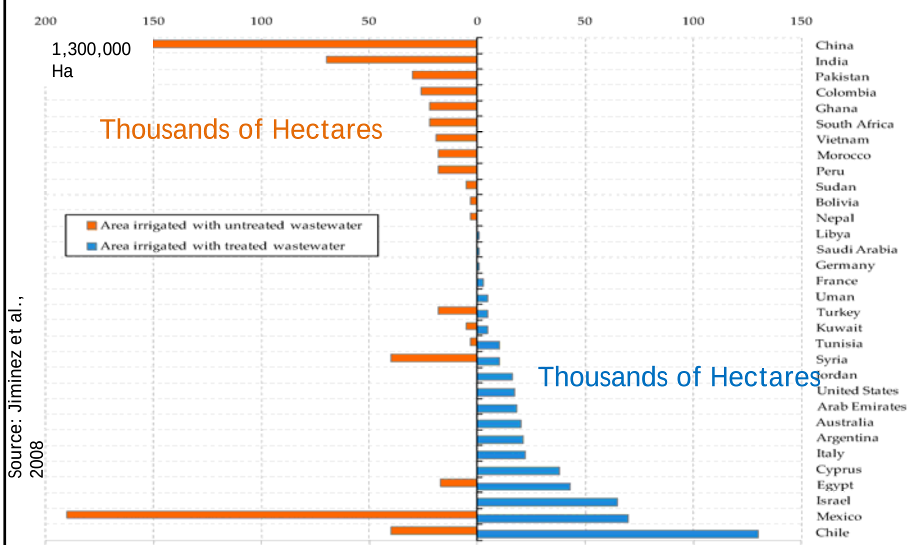
Evolution of Water Reuse

43

Irrigation with Raw Sewage

- Most common, globally
  - Only ~10% of wastewater is treated, world-wide
- Drivers: water scarcity and economics
- Example: Mezquital Valley, north of Mexico City
  - Huge public health issues
  - Health risks—Cholera, Dysentery, Typhoid
  - Farmers protesting wastewater treatment
- Lessons for safe water reuse
  - Learned and applied in Europe, Israel

44



Water Environment Federation the water quality people

45

Evolution of Water Reuse:

From **Agricultural Reuse**

to **Landscape Irrigation**

to **Industrial Reuse**

to **Groundwater Recharge**

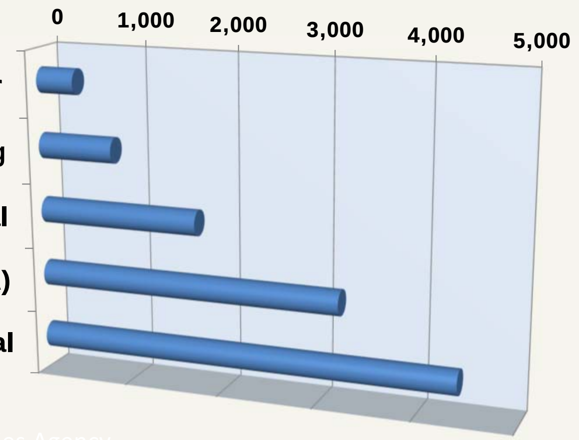
to **Indirect Potable Reuse**

to **Direct Potable Reuse**

Water Environment Federation the water quality people

46

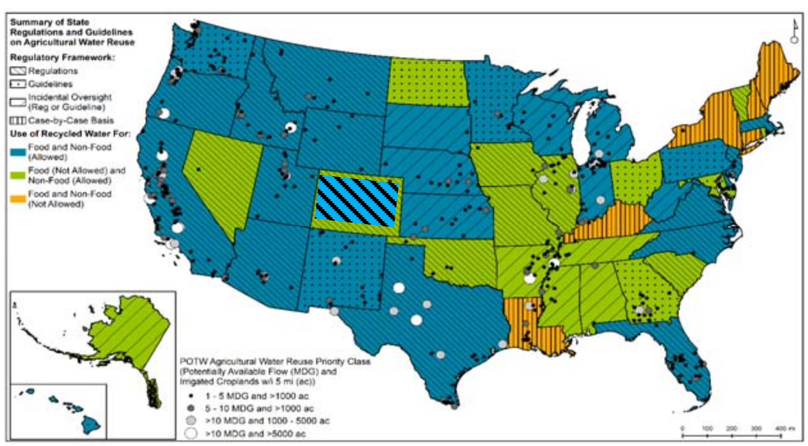
Energy Use, kWh/AF



SOURCE: Inland Empire Utilities Agency

47

State Regulations on Irrigation with Recycled Water



Number of States and Territories by Allowable Uses:
Food + Non-Food: 26; Non-Food: 19; Not Allowed: 7

48

Type of Use of Recycled Water	Stringency of Regulation
Agriculture, Non-Food Crops (fodder, fiber, seed crops)	**Least Stringent**
Construction uses (soil compaction, dust control)	
Environmental reuse (wetlands, streamflow augmentation)	
Processed Food Crops (Commercial Processing to Destroy Pathogens)	
Industrial Reuse (Cooling Towers)	
Aquaculture	
Agricultural Irrigation of Food Crops with No Direct Contact	
Restricted Recreational Impoundments (Boating, Fishing)	
Restricted Urban Irrigation (Golf Courses, Roadway Medians)	
Unrestricted Urban Irrigation (Parks, Playgrounds, Residential)	
Unrestricted Urban Impoundments (Full-Body Contact)	
Agricultural Irrigation of Food Crops Eaten Raw with Direct Contact	
Potable Reuse	**Most Stringent**

Water Environment Federation
the water quality people

49

Israel, Dan Region Project (SHAFDAN)

Groundwater Recharge Dedicated to Agricultural Irrigation

Water Environment Federation
the water quality people

50

Non-Potable Uses of Recycled Water

- Irrigation
- Supply for Ponds, Pools, Fountains
- Cooling, Air Conditioning
- Toilet Flushing, Priming Drain Traps
- Commercial Laundries
- Construction Water Uses
- Industrial Boiler Feed
- Car Washing
- Fire Fighting
- Mixing Concrete
- Dust Control
- Street Cleaning
- Snow Making
- Flushing Sanitary Sewers

Water Environment Federation the water quality people

51

Limtations of Non-Potable Water Reuse

Water Environment Federation the water quality people

52

Limitations of Non-Potable Reuse

- Distance from Source to Customer
- Separate Lines for Transmission, Distribution
- Congested Urban Areas and Utility Lines
- Cross-Connection Control/Backflow Prevention
- Signage, Color Coding, Warnings, Buffer Zones…
- Training of Site Supervisors
- Treatment Costs for Higher Water Quality
  - Removal of TDS, Nutrients…
- Low-Hanging Fruit Has Been (Mostly) Picked

Water Environment Federation the water quality people

53

Opportunities for Future Non-Potable Reuse

- In-Fill within Existing Networks
- Increased Deliveries to Existing Customers
- On-Site Reuse, District Water Reuse
- Sewer Mining
- Smaller, Isolated Areas

Water Environment Federation the water quality people

54

Competition with Potable Reuse

- Variable Case-by-Case Situations
- Tough Decision for Utility Mangers
  - Fast-Growing Urban Regions' Need for Municipal Water
  - Food-Water Nexus—Agriculture's Huge Demand for Water
- Potential for Stranded Investment
- Potential for Co-Existence of Potable and Non-Potable Reuse

Water Environment Federation
the water quality people

55

Thank You!

Water Environment Federation
the water quality people

56

Our Next Speaker

Germano Salazar-Benites
SWIFT Project Manager

swift

HRSD

Water Environment Federation
the water quality people

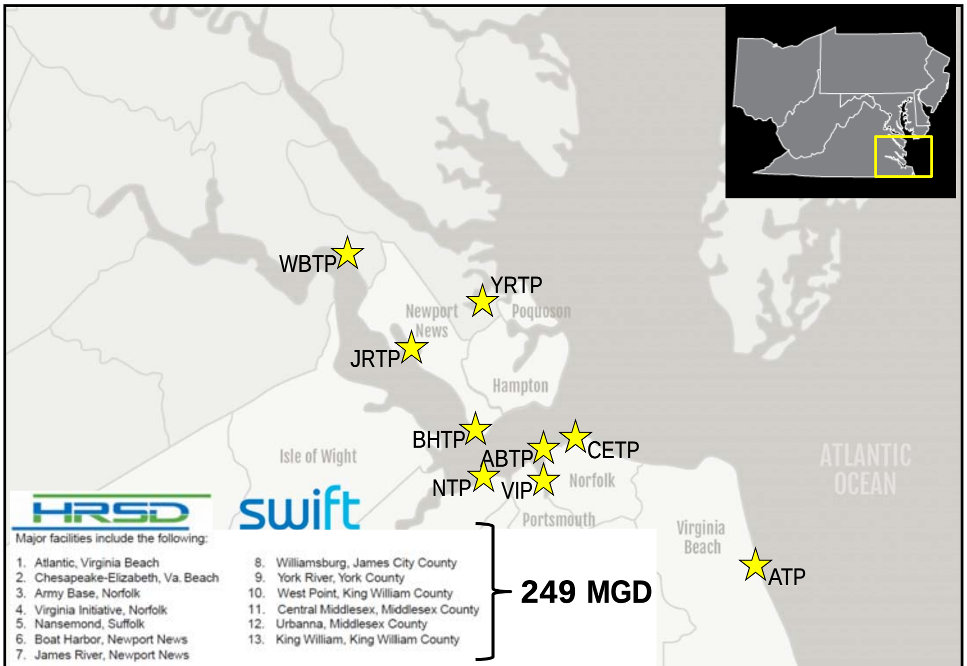
57

HRSD's Sustainable Water Initiative for Tomorrow (SWIFT), a "One Water" Approach to addressing Multiple Water Challenges.

Germano Salazar-Benites

Water Environment Federation
the water quality people

58



59

Eastern Virginia coastal systems are faced with a number of water related challenges.

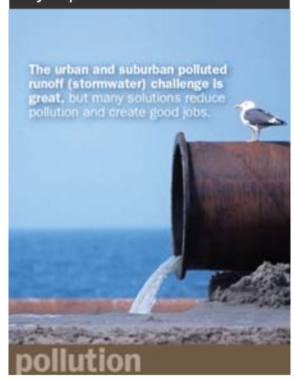
- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Sea level rise
  - Compounded by land subsidence
- Managing wastewater operations cost effectively in a fluid regulatory environment

60

Eastern Virginia coastal systems are faced with a number of water related challenges.

- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Sea level rise
  - Compounded by land subsidence
- Managing wastewater operations cost effectively in a fluid regulatory environment

2016 State of the (Chesapeake) Bay Report:

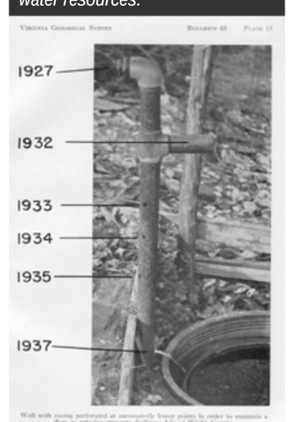


61

Eastern Virginia coastal systems are faced with a number of water related challenges.

- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Sea level rise
  - Compounded by land subsidence
- Managing wastewater operations cost effectively in a fluid regulatory environment

Physical evidence of declining water resources:



62

Eastern Virginia coastal systems are faced with a number of water related challenges.

- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Sea level rise
  - Compounded by land subsidence
- Managing wastewater operations cost effectively in a fluid regulatory environment

Norfolk, VA after Hurricane Matthew (2016):

Water Environment Federation the water quality people

63

Eastern Virginia coastal systems are faced with a number of water related challenges.

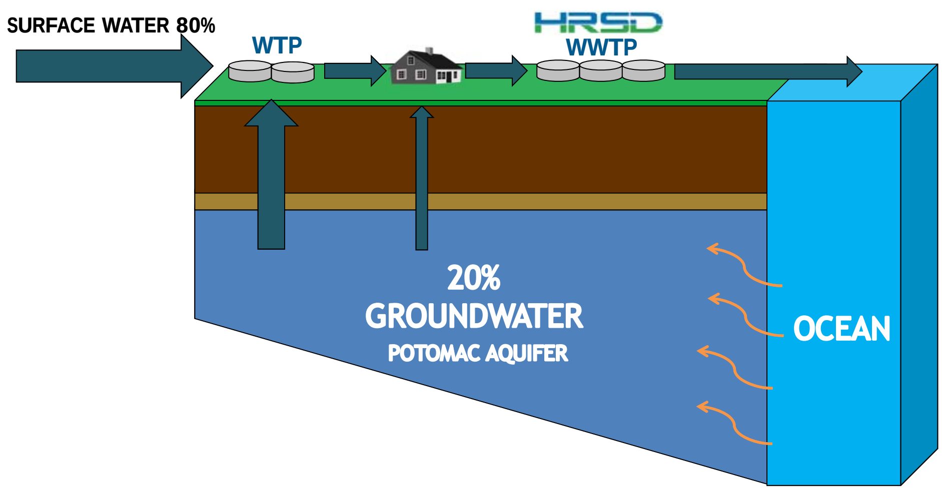
- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Sea level rise
  - Compounded by land subsidence
- Managing wastewater operations cost effectively in a fluid regulatory environment

Nearing completion, Nutrient Upgrades at HRSD's VIP Plant will meet less than 4 mg N/L objective – for a cost of roughly $150M

Water Environment Federation the water quality people

64

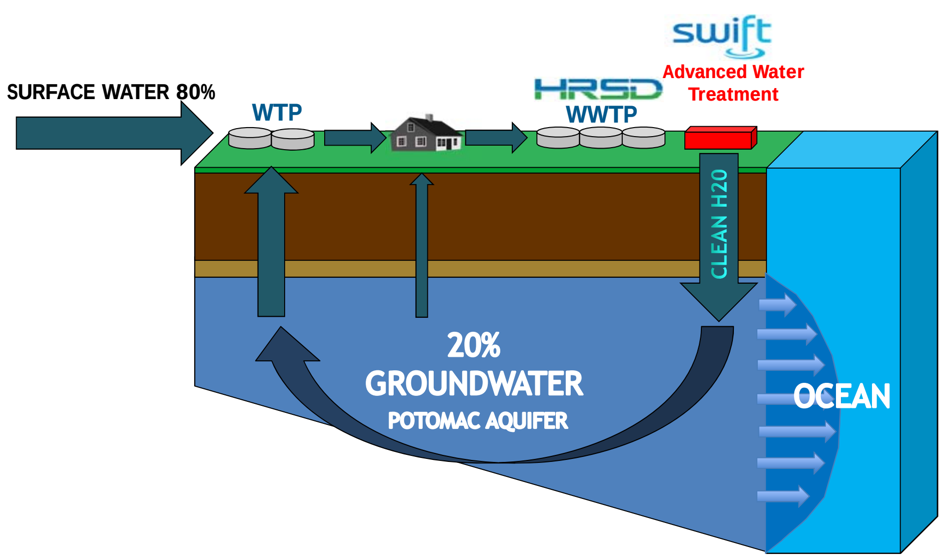
Current state of wastewater in Hampton Roads



Water Environment Federation
the water quality people

65

SWIFT - Sustainable Water Initiative for Tomorrow



Water Environment Federation
the water quality people

66

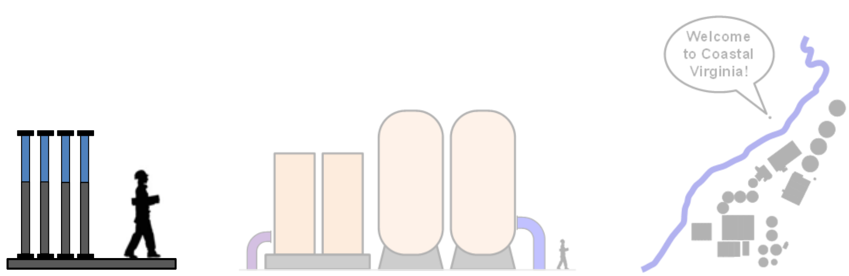
SWIFT is a Managed Aquifer Recharge project, with important outcomes for the region.

Purifying HRSD's already highly treated water to meet drinking water standards will create a valuable resource that can help:

- **Achieve** Chesapeake Bay restoration goals
- **Replenish** eastern Virginia's diminishing groundwater supply
- **Address** sea level rise
- **Support** our economy

67

SWIFT project phases

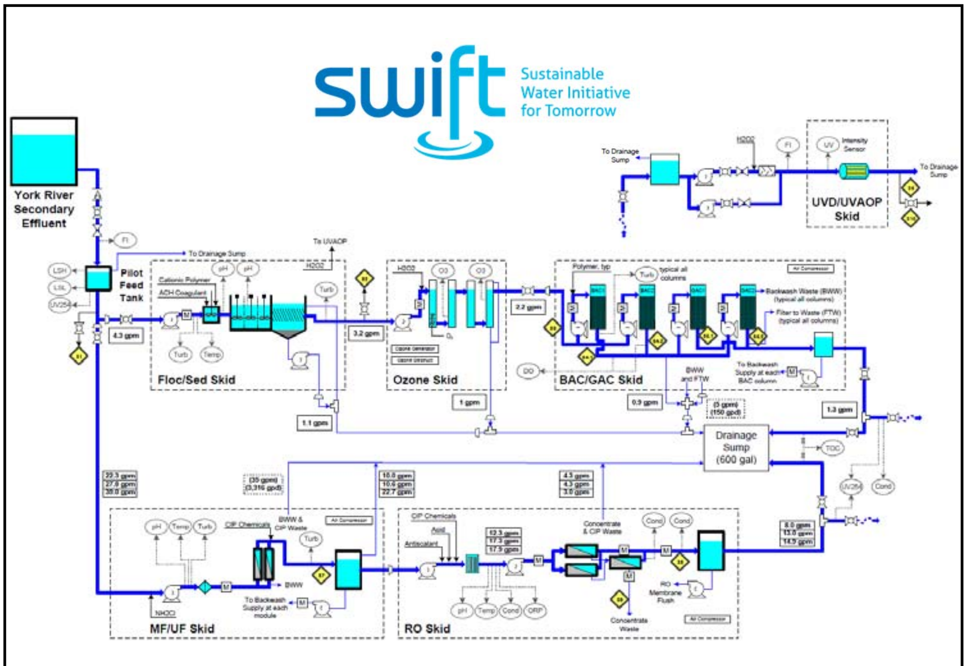


ca. 1:2,000 scale
Pilot Facility
Membrane based train
vs.
Carbon based train

ca. 1:15 scale
Research Center

> 100 MGD SWIFT
Build Out

68



69

Key points from pilot operation:

- Side-by-Side with UF/RO/UVAOP for 7 months
- Comparable CEC removal to parallel UF/RO/UVAOP process
- CEC (Eurofins 96) list ok – nothing approaching our action level (10% of target) except 1,4-dioxane
- All Primary MCLs routinely met
- 500-600 mg TDS/L in SWIFT water
- TOC remaining below 4 mg/L TOC through nearly 2 years of operation

Water Environment Federation
the water quality people

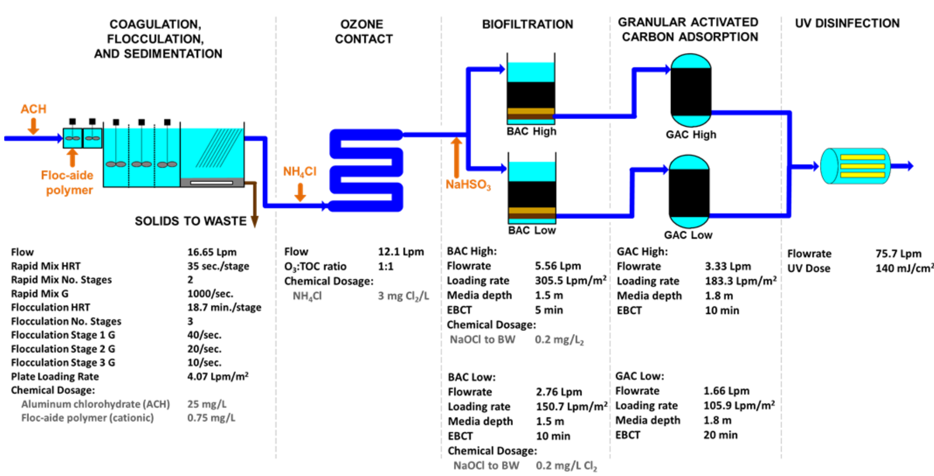
70

Current research thrusts:

- Optimization of ozone contact & bromate control (P. Buehlmann, M. Pearce, et al., VTech)
- Pre-oxidation for bromate control (S.Hogard, et al VTech)
- Enhancement of 1,4-dioxane and NDMA degradation in biofiltration (R. Vaidya, et al., VTech)
- Soil aquifer treatment for organics and microbial pollutants (P. Pradhan, Thomas Dziura et al., VTech)

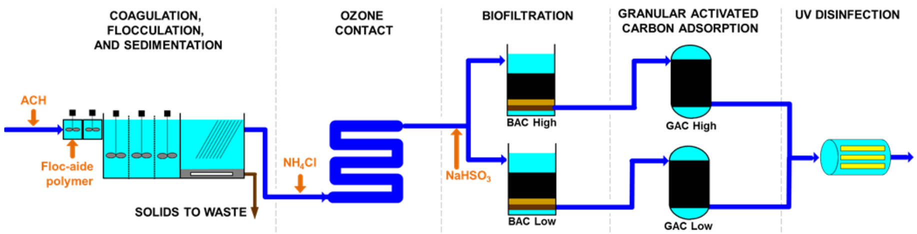
71

Pilot system operation served as basis for design of 1 MGD demonstration facility



72

Pilot system operation served as basis for design of 1 MGD demonstration facility



COAGULATION, FLOCCULATION, AND SEDIMENTATION	OZONE CONTACT	BIOFILTRATION	GRANULAR ACTIVATED CARBON ADSORPTION	UV DISINFECTION
No major changes from the pilot… 0.3 gpm/sf loading rate	Residual control of O_3 at max dosage of 20 mg O_3/L Operation for 3 LRV	12 minute EBCT with 4 BAFs in service	30 minutes EBCT with 2 GAC vessels in service Parallel or Series operation	186 mJ/cm^2 UV dose designed for 4 LRV (virus) 12:10:10 total LRV possible prior to SAT

Water Environment Federation the water quality people

73

DRAFT water quality targets have been developed collaboratively with regulators and technical reviewers

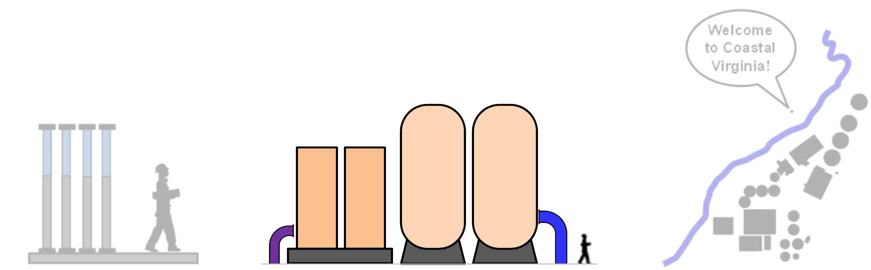
Including Bromate

	Proposed Regulatory Limit	Water Quality Goal
Maximum Contaminant Limits	Meet all primary MCLs	Not Applicable
Total Nitrogen	5 mg N/L monthly; 8 mg N/L max daily	Critical Control Point: Secondary Effluent TIN < 6 mg N/L
Turbidity	IFE < 0.15 NTU 95%ile; < 0.3 NTU back-to-back	Critical Control Point: Backwash or Filter Standby at 0.10 NTU
Total Organic Carbon	4 mg/L monthly; 6 mg/L maximum	Critical Operating Point Action at 4 mg/L laboratory 10-day average
Total Coliform	< 2 CFU / 100 mL 95%ile; < 3 CFU / 100 mL 20 day geo. mean	Log reduction values of 12 – 10 – 10 for virus, Cryptosporidium, and Giardia, respectively
E. coli	Non-detect	
Total Dissolved Solids	None	Aquifer compatibility
Unregulated Constituents	None	Monitor and address

Water Environment Federation the water quality people

74

SWIFT project phases



ca. 1:2,000 scale Pilot Facility

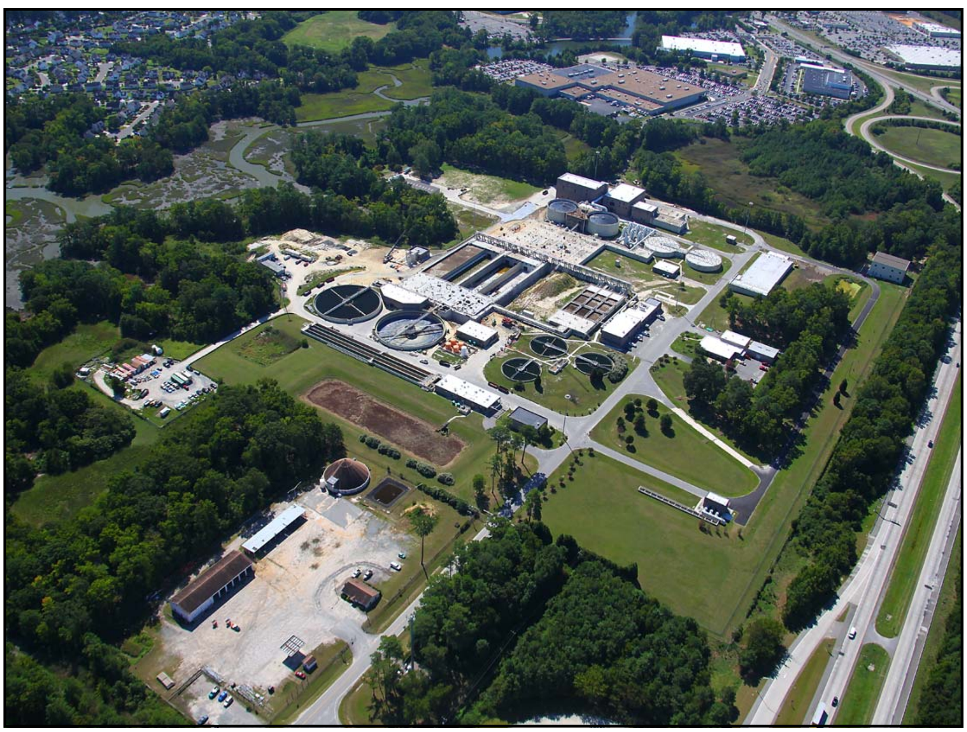
ca. 1:15 scale Research Center

> 100 MGD SWIFT Build Out

- Extensometer
- Monitoring Wells
- Process Area

Water Environment Federation
the water quality people

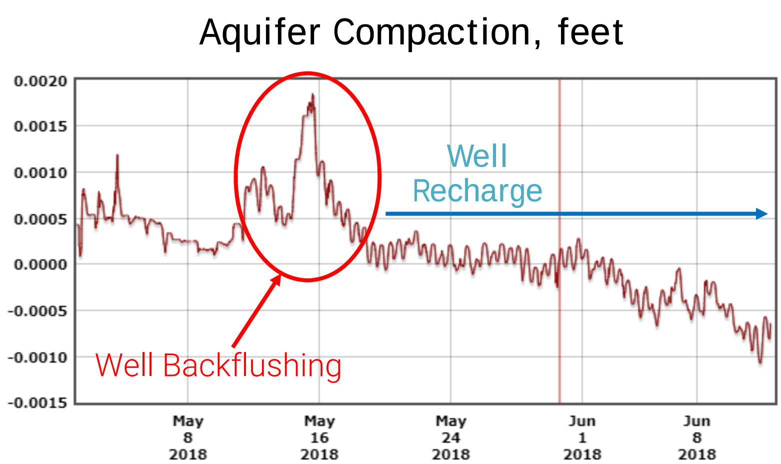
75



76

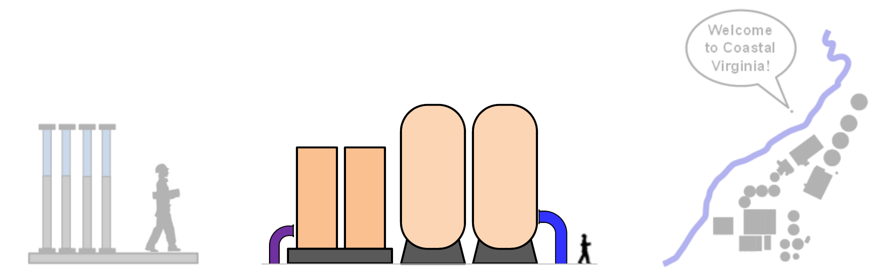
77

Tracking groundwater recharge through USGS extensometer



78

SWIFT project phases



ca. 1:2,000 scale Pilot Facility

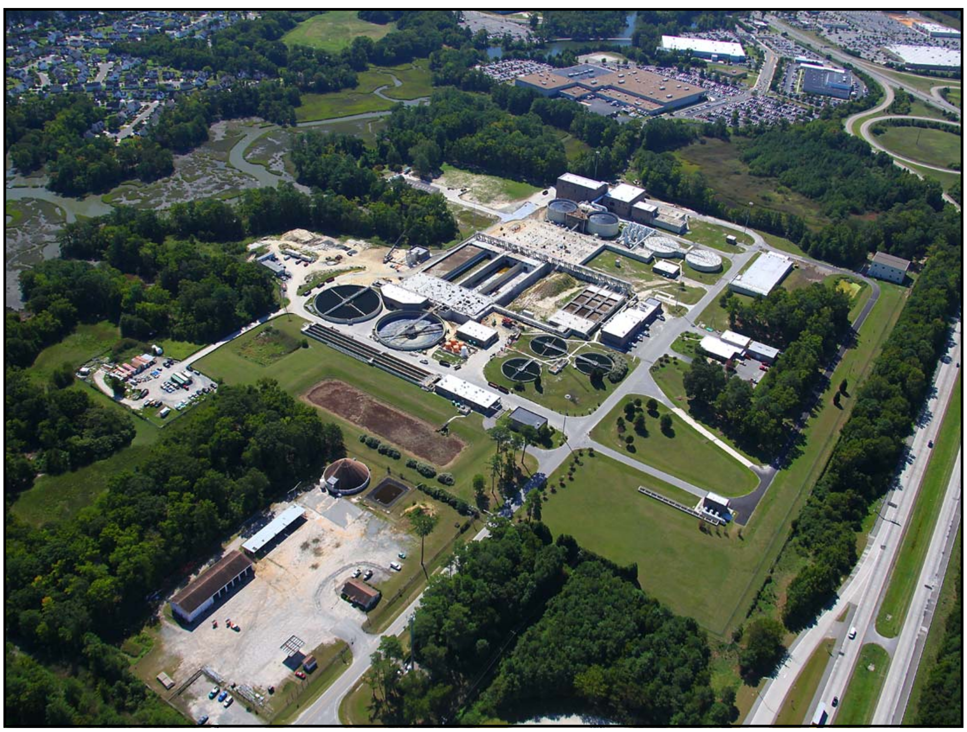
ca. 1:15 scale Research Center

> 100 MGD SWIFT Build Out

- Extensometer
- Monitoring Wells
- Process Area

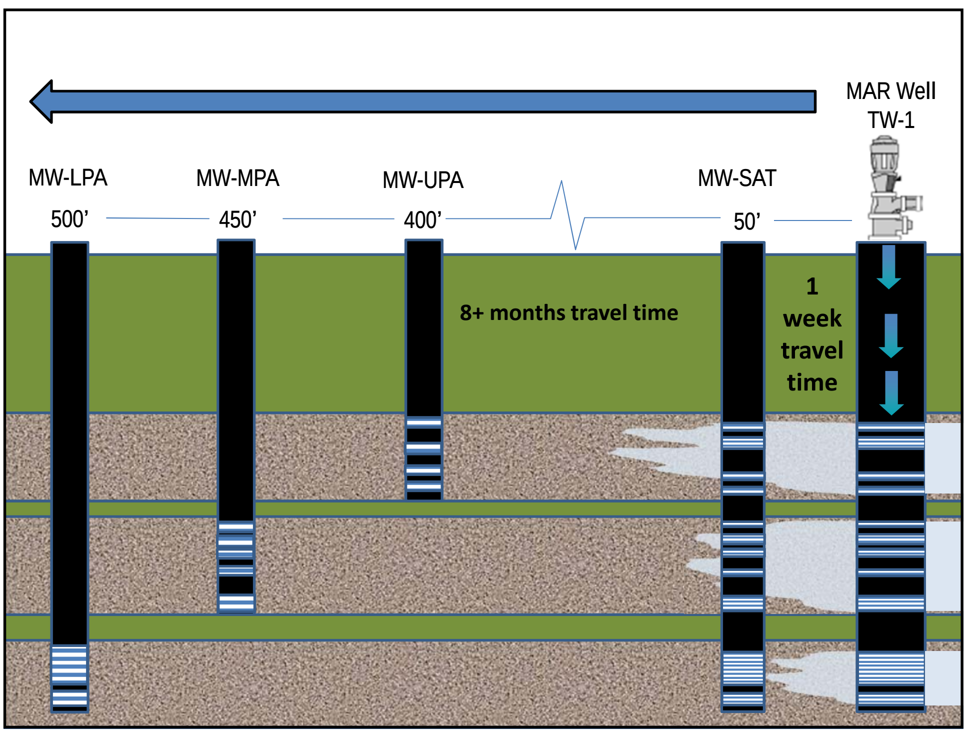
Water Environment Federation
the water quality people

79



80

81

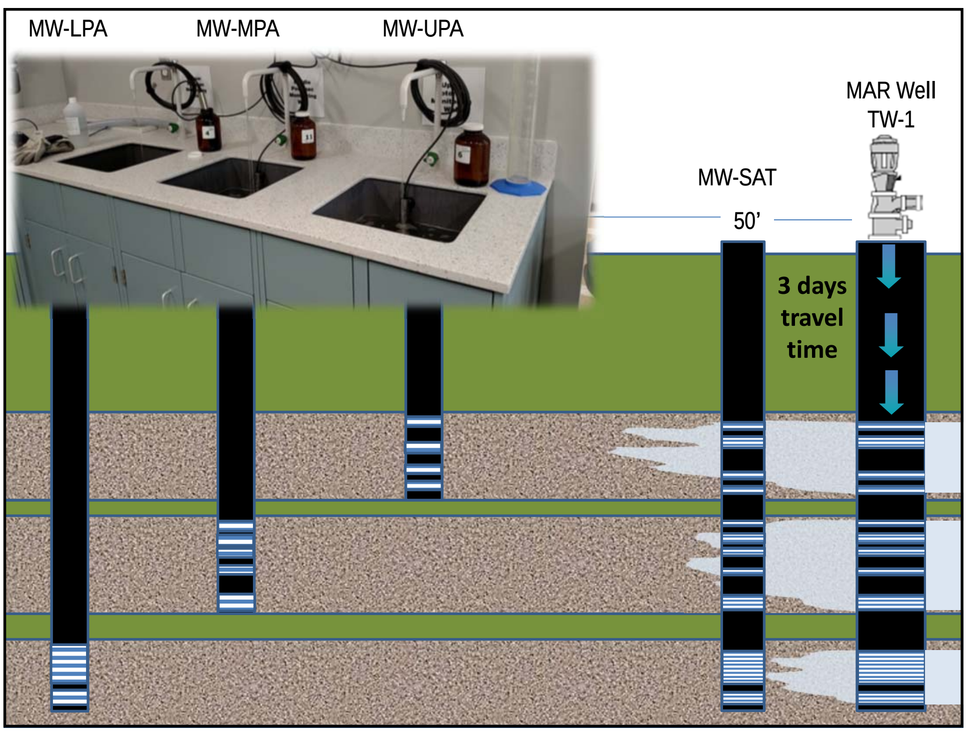

MAR Well
TW-1
MW-LPA
MW-MPA
MW-UPA
MW-SAT
500’
450’
400’
50’
8+ months travel time
1
week
travel
time

82

FLUTe Monitoring System installed in MW-SAT
Depth and screened sections match the recharge well – 1420 ft
Samples retrieved from each of the 11 screened sections

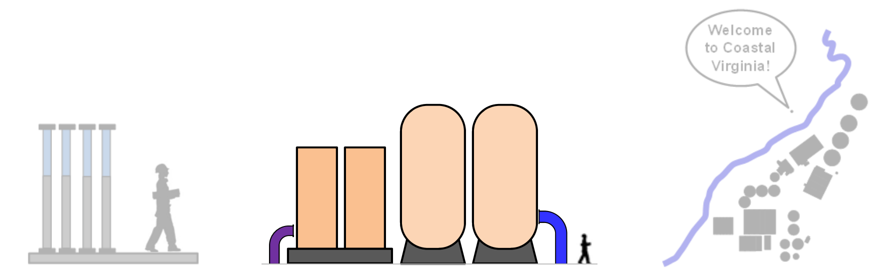
Water Environment Federation
the water quality people

83



84

SWIFT project phases



ca. 1:2,000 scale Pilot Facility

ca. 1:15 scale Research Center

> 100 MGD SWIFT Build Out

- Extensometer
- Monitoring Wells
- Process Area

Water Environment Federation
the water quality people

85

Water Environment Federation
the water quality people

86

First online on April 9^{th}, 2018
Routinely producing settled water < 0.4 NTU

87

First online on April 10^{th}, 2018
Residual control (0.3 ppm, 3 LRV Virus)
Roughly 50% sidestream flow
Relocation of NH_4Cl at injector
Bromide well controlled
- daily samples for Br^- and BrO_3^-

88

First online April 12th, 2018
Virgin carbon = It's just GAC
Routinely producing filtered water < 0.08 NTU
Low head gain from solids; periodic "bump" needed to release bubbles

Water Environment Federation
the water quality people

89

First online on April 17th, 2018
Operating in parallel initially
Likely operate in series long term

Water Environment Federation
the water quality people

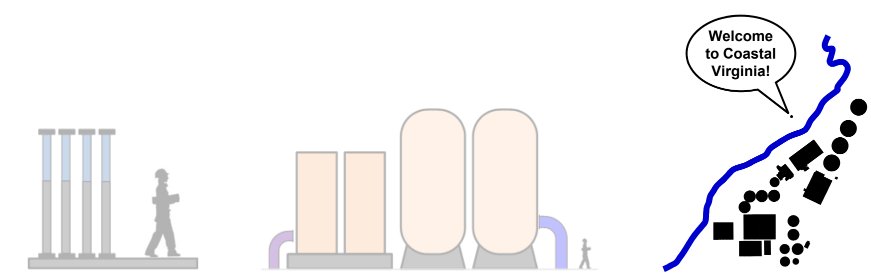
90

First online on April 17th, 2018 (SWIFT Water!!)
Testing for NDMA photo-oxiation prior to BAF acclimation

- up to 600 mJ/cm^2 at reduced/split flowrates
- Designed to achieve 4 LRV.

91

SWIFT project phases

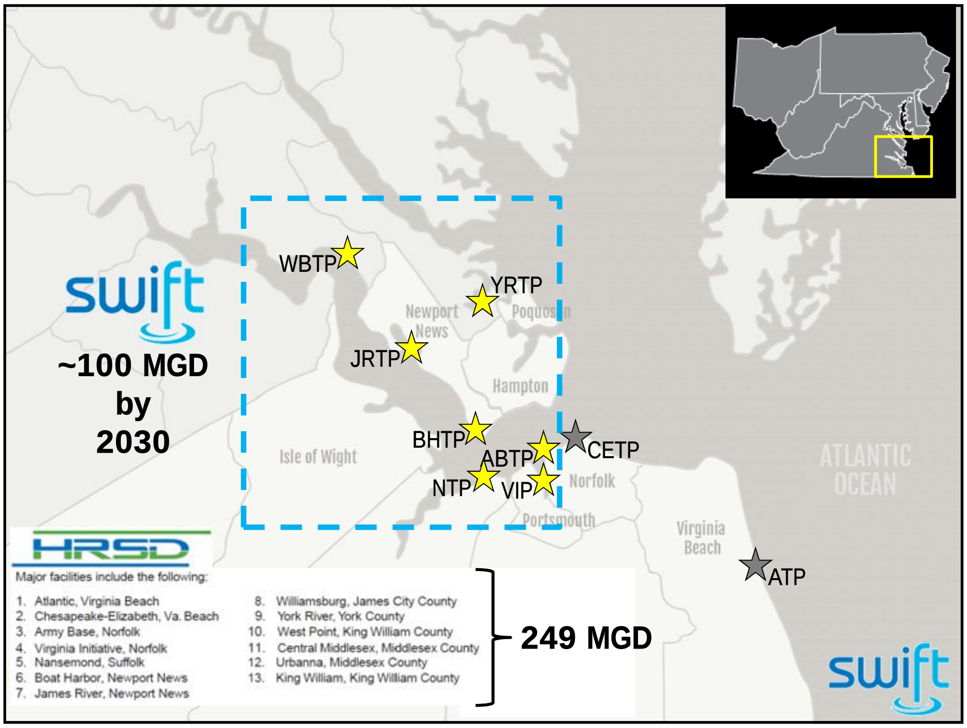


ca. 1:2,000 scale Pilot Facility

ca. 1:15 scale Research Center

> 100 MGD SWIFT Build Out

92



93

Immediate Next Steps:

On-going regulatory sampling
Recharge began May 15th!
Dedication Ceremony, May 18th
Family Open House, May 19th
UIC permit by 2019

www.swiftva.com

Water Environment Federation
the water quality people

94