

MALCOLM
PIRNIE

Water Quality Planning: Membrane and UV Applications



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Overview of Presentation

- Water Quality Master Planning
- Planning considerations for UV & membranes
- Case study
- Some closing remarks

Benefits of Water Quality Master Planning

- Less risk of obsolescence of capital improvements
- Prioritizes capital improvements program
- Provides common vision of the future
- Stays ahead of regulations
- Cost efficiencies
- Utility controls its future

Water Quality Master Plan Answers Three Questions

- Where are we at?
- Where do we want to go?
- How do we get there?

Program "Map" Defines Process

- Source Waters
- Treated Water
- Delivered Water

Assess Existing
WQ

- Treatment processes
- Conveyance systems
- Water age

Facility &
Process Review

- Who does what?
- Skills
- Training
- Priorities

Organizational
Review

Program "Map" Defines Process

Assess Existing
WQ

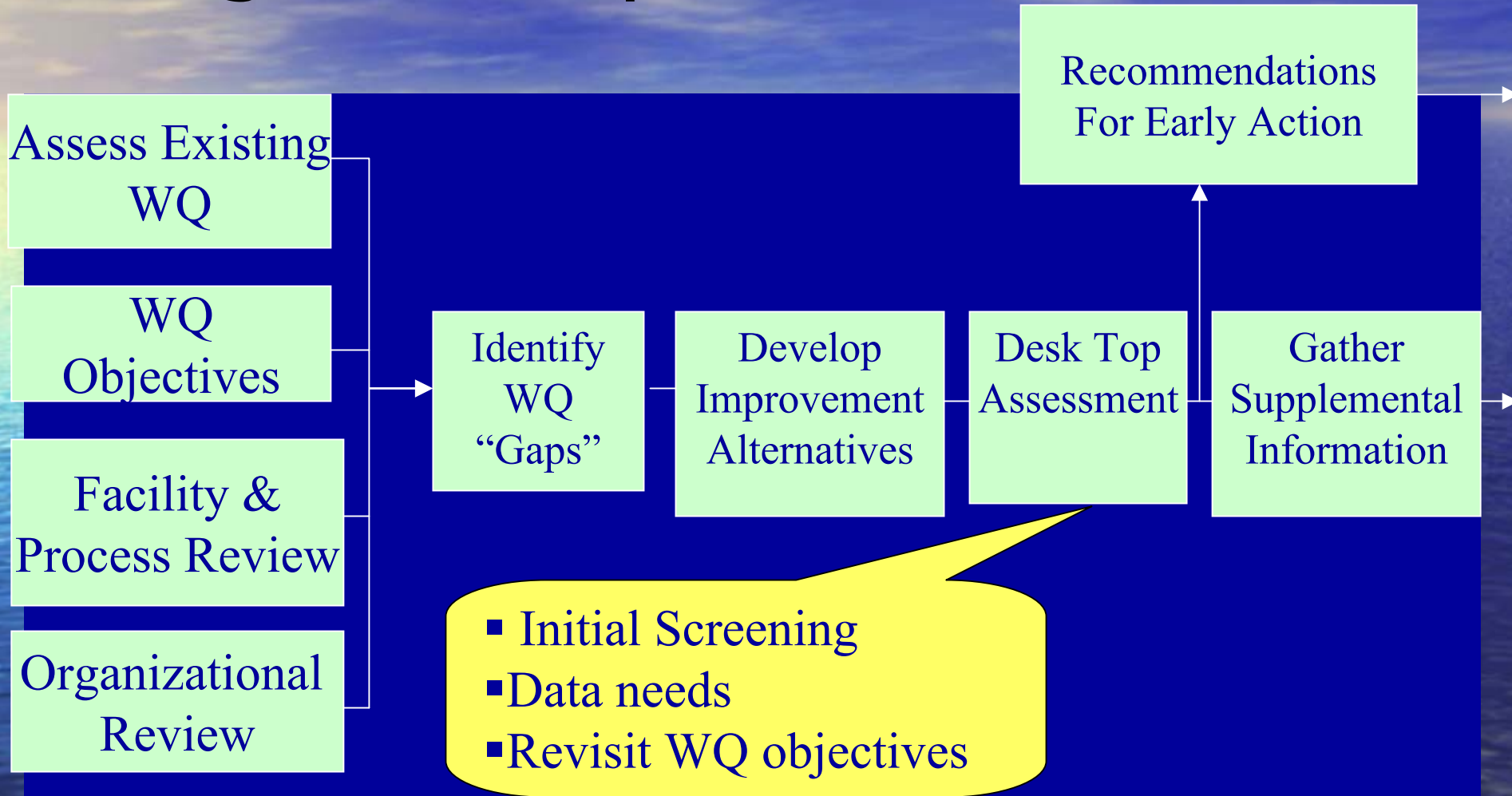
WQ
Objectives

Facility &
Process Review

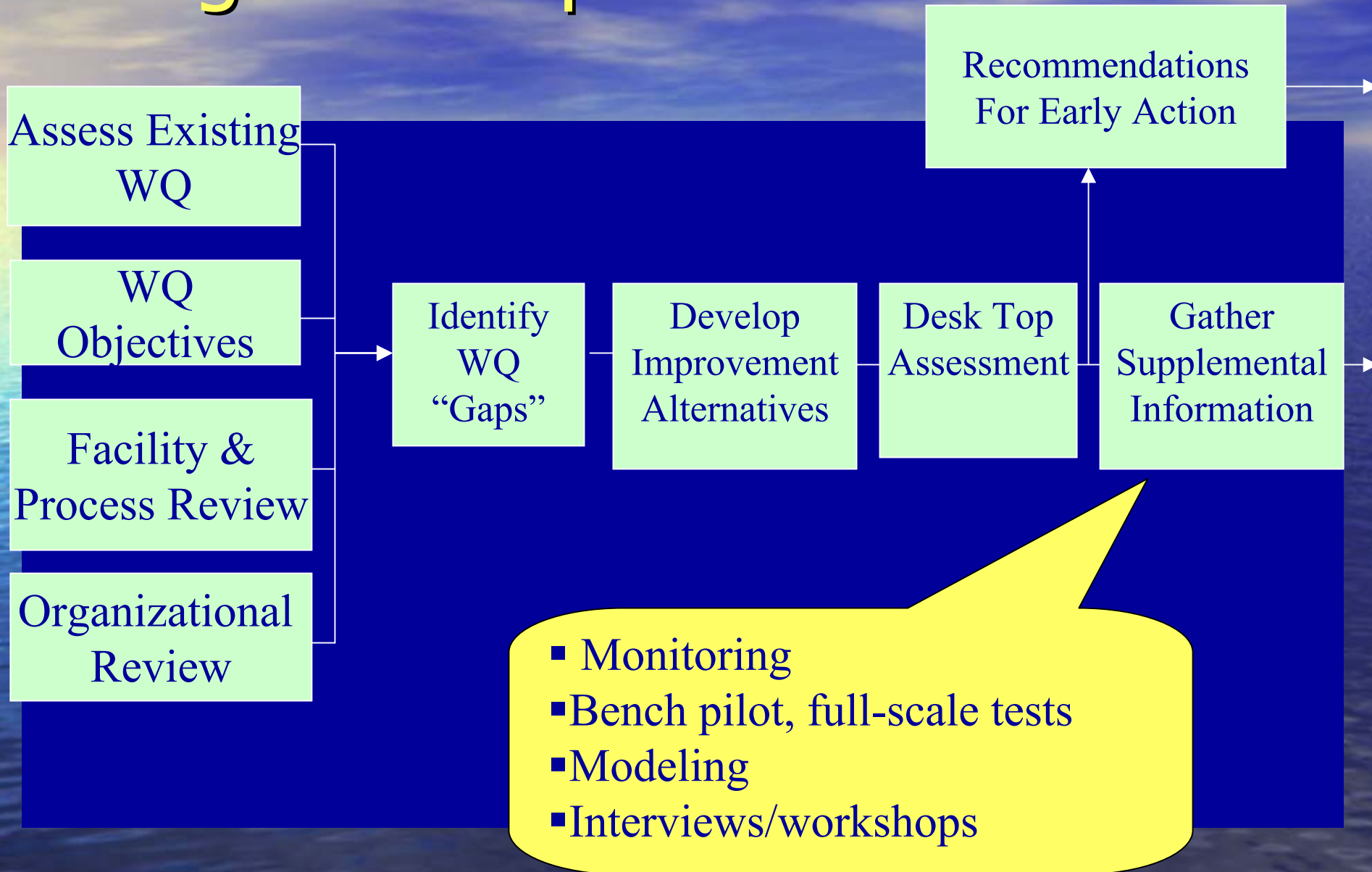
Organizational
Review

- Compliance
- Utility goals
- Address uncertainties

Program "Map" Defines Process

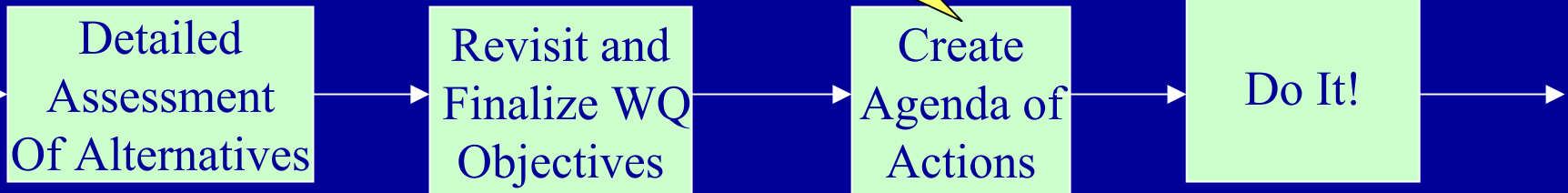


Program "Map" Defines Process



Program "Map" Defines Process

- Schedule/staging
- Decision points
- Costs



Membranes and UV:

What do they do?

- First and foremost, they are primary disinfectants
- Filters are our most robust primary disinfectant

UV and Membranes: What do they do?

"True" Multiple Barrier

Physical Removal + Inactivation = Primary Disinfection

SWTR requires 3-log *Giardia*

Physical Removal

Conventional
Filtration

2.5

+

+

Inactivation

Free Cl₂
Disinfection

0.5

=

=

Primary Disinfection

3 log

Membranes and UV:

What do they have in common?

- Strongest barriers to cysts
- No “known” DBPs
- No oxidation
- No T&O control

Sample Inactivation Data

Target Organism	Inactivation	Dose (mJ/cm ²)
Bacteria	4-log	3-12
<i>Crypto & Giardia</i>	3-log	14
Rotavirus	4-log	55
Adenovirus	4-log	215

Giardia Removal Studies

<u>Researcher</u>	<u>Year</u>	<u>Process</u>	<u>Log Removal</u>
Jacangelo, et al.	1997	MF	> 7.0*
Olivieri, et al.	1987	MF	5.6
Schneider, et al.	1999	MF	> 4.8
Kachalsky, et al.	1993	MF	6.6*
Jacangelo, et al.	1997	UF	> 6.9*
Dwyer, et al.	1995	UF	> 5*
Trussel, et al.	1998	UF	> 5.1*
Kachalsky, et al.	1993	UF	7.4

* Indicates removed below detection limit

Crypto Removal Studies

<u>Researcher</u>	<u>Year</u>	<u>Process</u>	<u>Log Removal</u>
Jacangelo, et al.	1997	MF	> 6.8*
Olivieri, et al.	1989	MF	4.8
Schneider, et al.	1999	MF	> 4.2
Kachalsky, et al.	1993	MF	5.7
Jacangelo, et al.	1997	UF	> 4.8*
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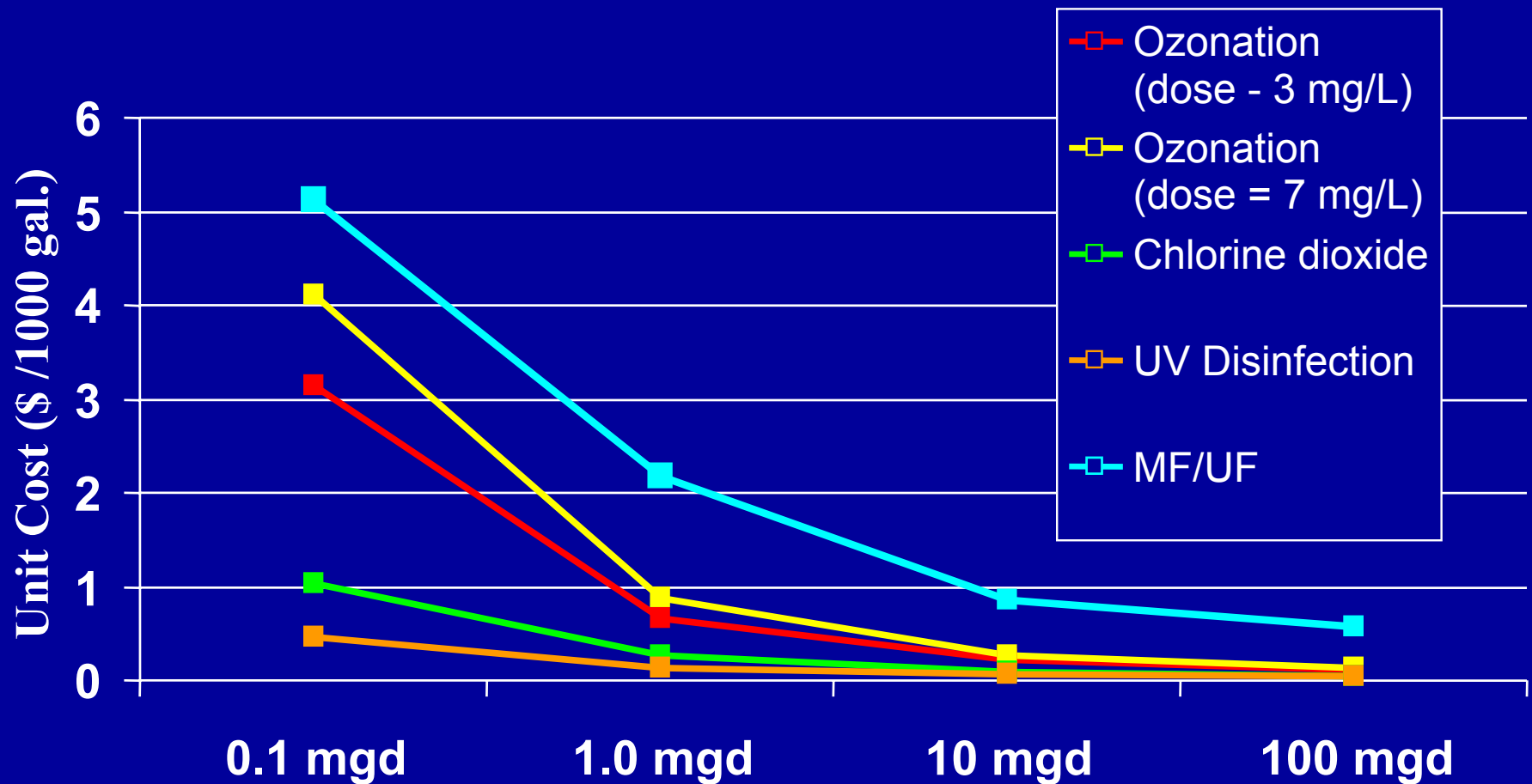
* Indicates removed below detection limit

Membrane and UV:

What don't they have in common?

- Disinfection mechanism
 - Membranes → Physical Removal
 - UV → Inactivation
- Membranes remove particles
- Cost

Unit Cost of Treatment for Crypto



Membrane and UV: Value Comparison

	10 mgd	100 mgd
Membrane	0.9	0.7
UV	0.1	0.05

**\$/k-gal
Total Cost**

What is the value of cost difference?

- Particle removal
- Lower uncertainty over level of treatment

Traditional approach to “multiple barrier” is being challenged







Filtration + chlorination = unprecedented success

The Challenges

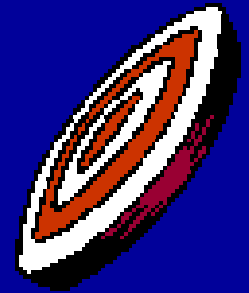
- *Cryptosporidium*
- LT2
- Membranes
- DBP Control
- Doing more with less

"Sweet Spot" Applications

- Reg-Neg Forecasts
- LT2/Stage 2 compliance

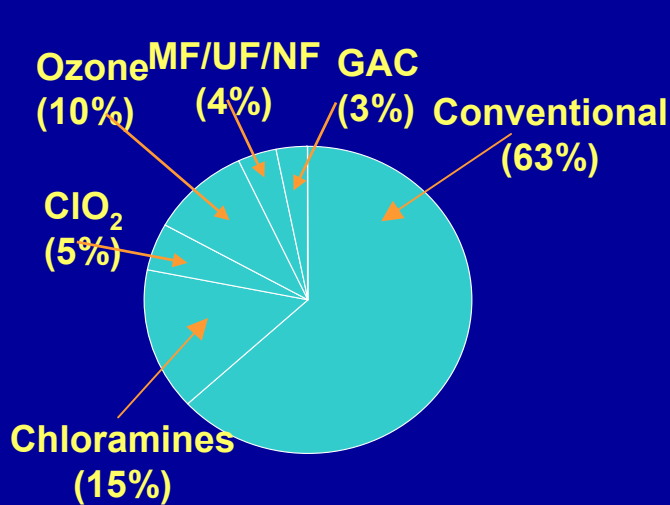
	Total Log	UV with conventional	MF or UF
Bin 1	3	-	
Bin 2	4		
Bin 3	5		
Bin 4	5.5		?

- Rebuild multiple barriers
- New WTPs → membranes
- Filter expansions or replacement → membranes

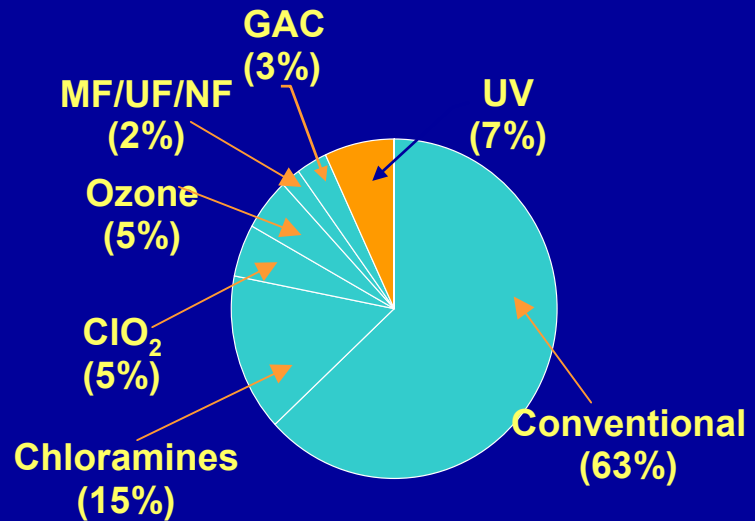


Draft Compliance Forecast

Running Annual Average 80/60
No Additional *Crypto* removal/inactivation



UV not included

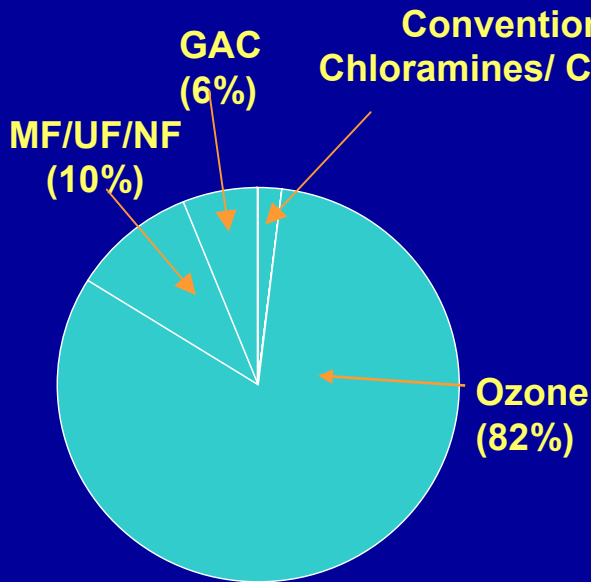


UV included

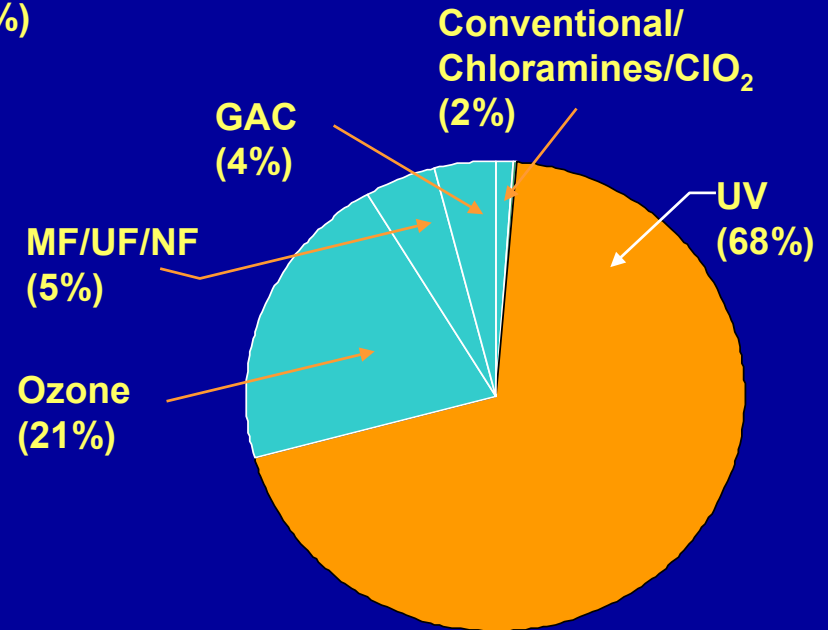
Preliminary Draft: Working group document subject to change.

Draft Compliance Forecast

Maximum Location Running Annual Average 80/60
Additional 1 log *Crypto* removal/inactivation



UV not included



UV included

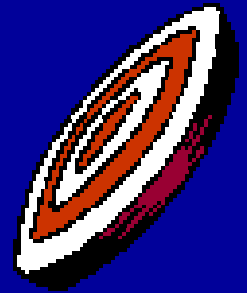
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"Sweet Spot" Applications

- Reg-Neg Forecasts
- LT2/Stage 2 compliance

	Total Log	UV with conventional	MF or UF
Bin 1	3	-	☑
Bin 2	4	☑	☑
Bin 3	5	☑	☑
Bin 4	5.5	☑	?

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- New WTPs → membranes
- Filter expansions or replacement → membranes



Rivertown, USA

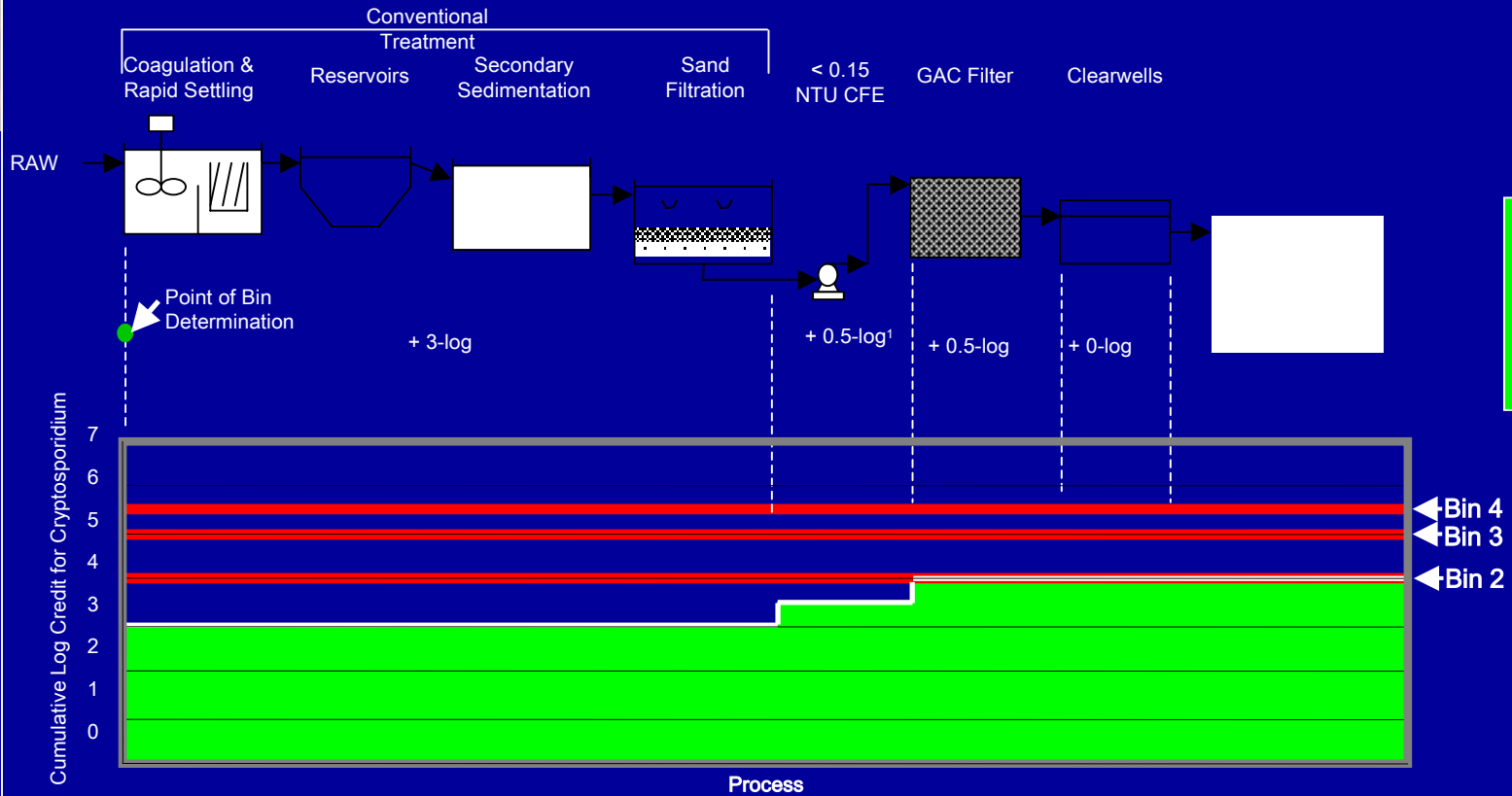
Strategic Planning for Disinfection

- Identify future water treatment processes
 - Meet existing, future water quality goals and regs
 - Provide additional barriers against microbial contaminants
 - Align with overall mission & strategic business plan
- UV & membranes investigated
 - Conceptual facility alternatives
 - Bench-scale UV testing

UV & Membrane Conceptual Facility Comparison

	UV	Membranes
Advantages	<ul style="list-style-type: none"> • Meets LT2ESWTR requirements • Multi-barrier protection (additional inactivation barrier) • Enhanced inactivation of unregulated organisms • \$53-60M present worth 	<ul style="list-style-type: none"> • Meets LT2ESWTR requirements • Multi-barrier protection (additional physical barrier) • Enhanced removal of unregulated organisms • No potential to form DBPs
Disadvantages	<ul style="list-style-type: none"> • Potential for future identification of DBPs not currently known • Potential for DNA repair • Potential for microbial regrowth • Potential for increases in DBPs 	<ul style="list-style-type: none"> • Contaminants smaller than pore size will not be removed (prions?) • Single inactivation barrier • \$170M present worth

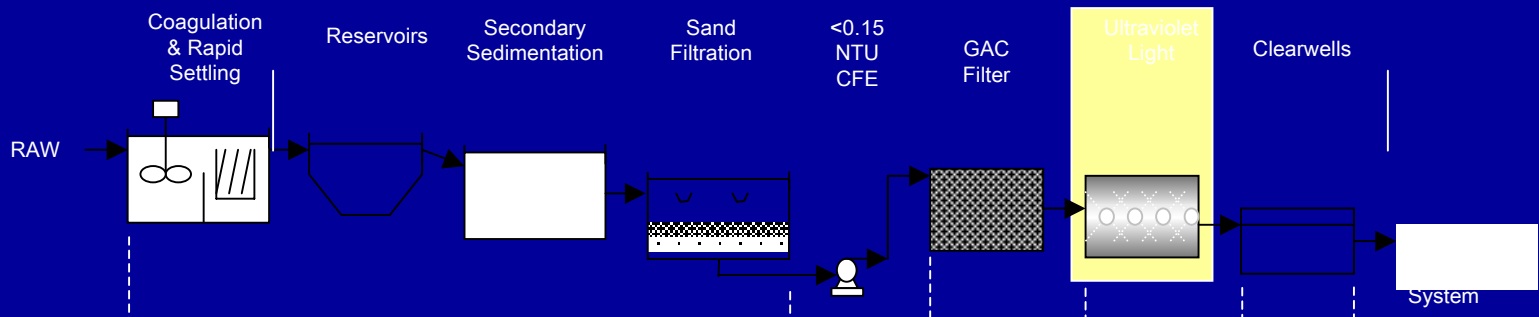
Baseline Scenario: Current Treatment Process



Indicates that credit was achieved using a physical removal barrier.

Scenario B: Post-GAC UV Light

Conventional Treatment

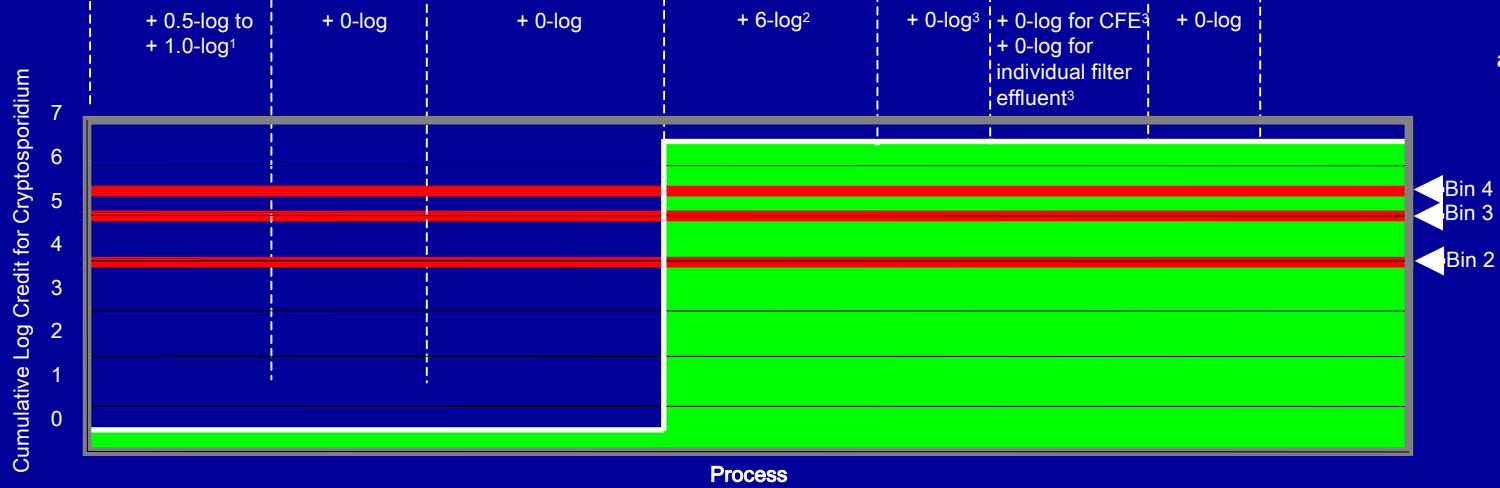
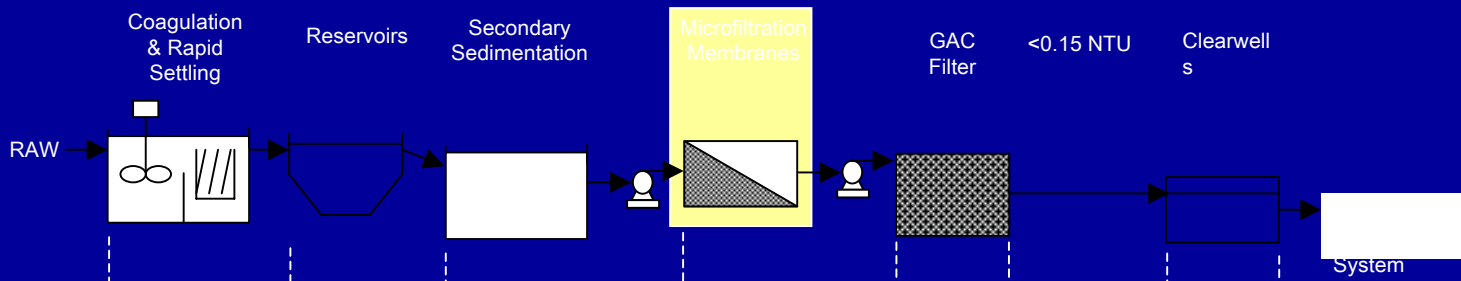


Indicates that credit was achieved using a physical removal barrier.

Indicates that credit was achieved using an inactivation barrier.

Bin 4
Bin 3
Bin 2

Scenario C: Settled Water MF and Rapid Sand Filters Abandoned



Indicates that credit was achieved using a physical removal barrier.

Summary - Rivertown

- UV & membranes are each able to meet future water quality goals and regulations
- UV followed by free chlorine was effective against all organisms tested
- No increase in DBPs or AOC

Summary - Rivertown

- Strategic business plan “futures” workshop indicated UV will play a role in future
- UV enhances multi-barrier protection by providing an additional *inactivation* barrier

In Closing...

- Master plan WQ just as you do your other assets
- Plan disinfection comprehensively – not as individual technologies
- You have to decide what "*multiple barrier*" means to you
- Don't limit the future to today's bad stuff and technologies
- Eventually you're going to have to get it out of the water - plan for technologies that do this