

Overcoming the Challenges of a Minimum Continuous UV Dose Requirement for Disinfection of Secondary Effluent

NEWEA & NYWEA 2023 Joint Spring Meeting – June 7, 2023

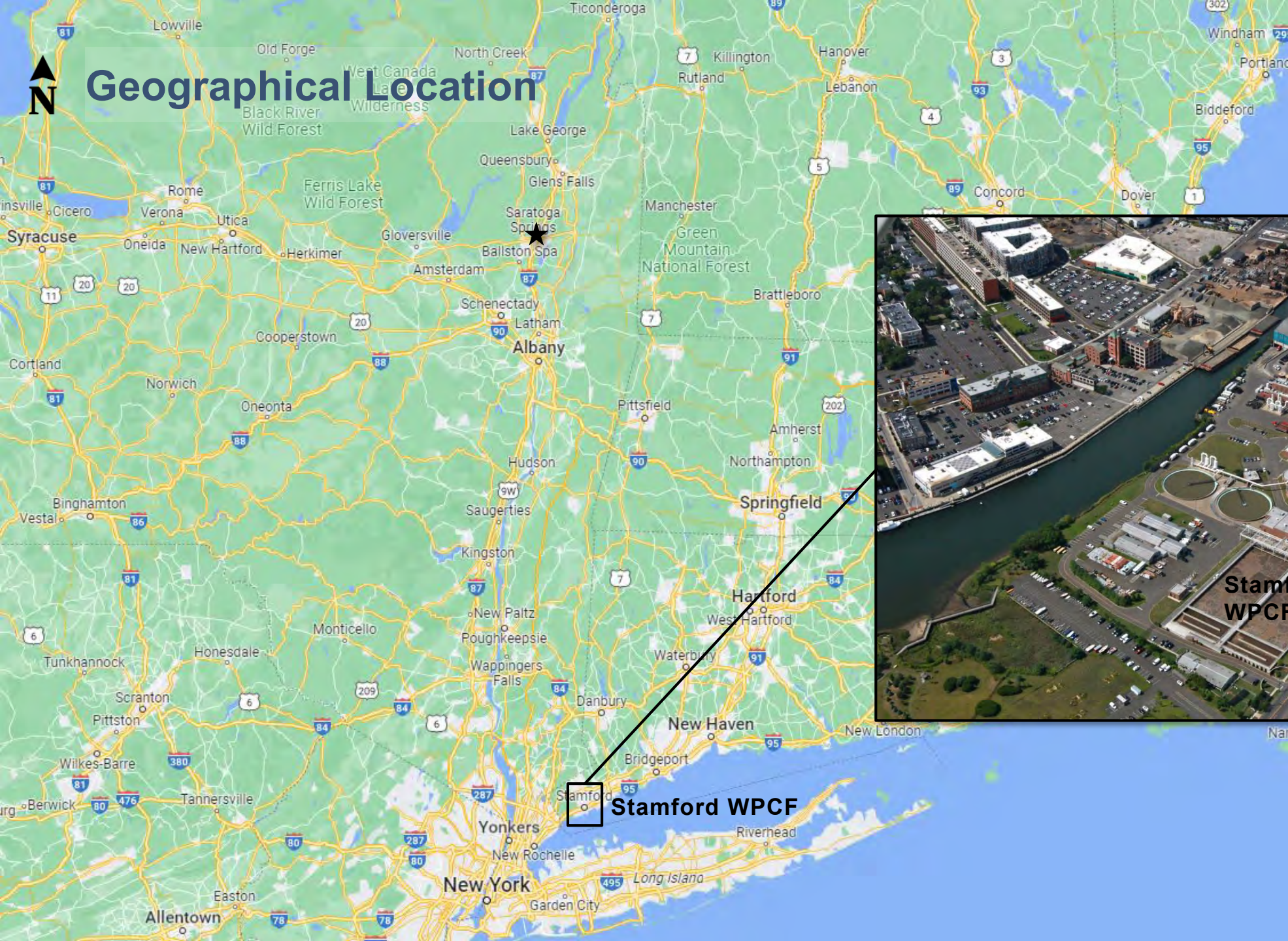
Agenda

- Stamford WPCF background
- Drivers for UV disinfection system upgrade
- Field and laboratory sampling and testing
 - Field sampling
 - Collimated beam testing
- Design approach and configuration
 - Alternatives analysis and selected alternative
 - Pre-selection of UV disinfection equipment
- Construction sequencing and system commissioning

Stamford WPCF Background



Geographical Location



Stamford WPCF

Plant Characteristics and Layout

- Design capacity
 - Annual average flow = 24 mgd
 - Peak wet-weather flow = 68 mgd
- 4-stage Bardenpho process
 - Biological nitrogen removal
- Unit processes
 - 2 primary clarifiers
 - 2 aeration trains
 - 4 secondary clarifiers
- Ultraviolet (UV) disinfection of secondary effluent
- Final effluent pumping

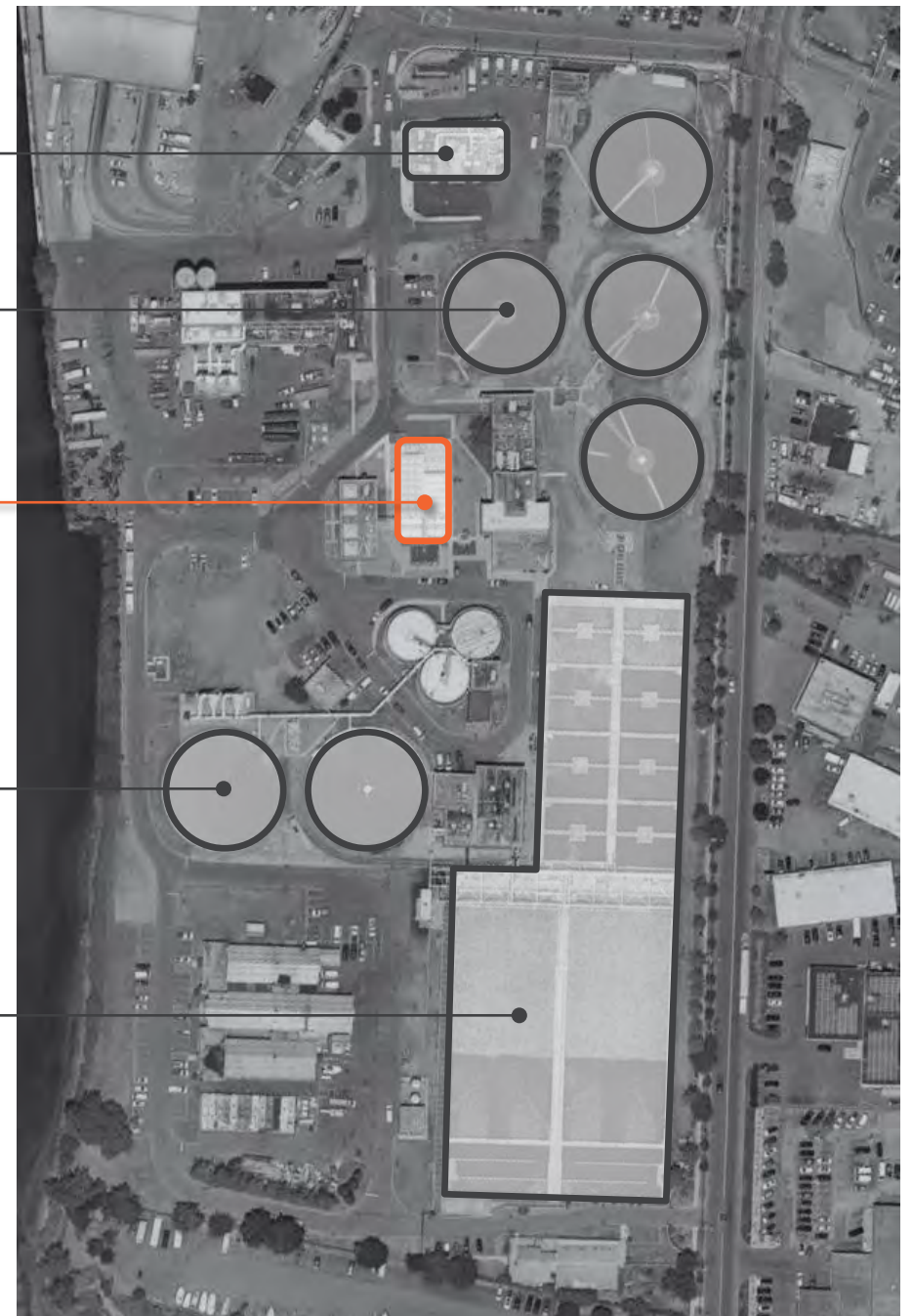
Influent PS

Four (4)
Secondary Clarifiers

UV Disinfection
& Final Effluent PS

Two (2)
Primary Clarifiers

Two (2)
Aeration Trains



NPDES Permit Limits for Disinfection

Parameter	Sampling Frequency	Sampling Type	Limit	Notes
Bacteriological Limits				
Fecal coliform	3 / week	Grab	88 cfu / 100 mL	Monthly geometric mean
Fecal coliform	3 / week	Grab	< 10%	% of samples/month with > 260 cfu / 100 mL
Fecal coliform	3 / week	Grab	2,400 cfu / 100 mL	Maximum
Enterococcus	3 / week	Grab	35 cfu / 100 mL	Monthly geometric mean
Enterococcus	3 / week	Grab	500 cfu / 100 mL	Maximum
UV-Specific Limits				
UV Dose	Continuous	N/A	≥ 30 mW-sec / cm ²	Minimum
UV Transmittance	Work day	Grab	N/A (%)	Monitoring only

Drivers for UV Disinfection System Upgrade

Drivers for UV Disinfection System Upgrade

- Existing system did not have redundancy at peak wet-weather flow of 68 mgd
 - TR-16 reliability for UV disinfection equipment

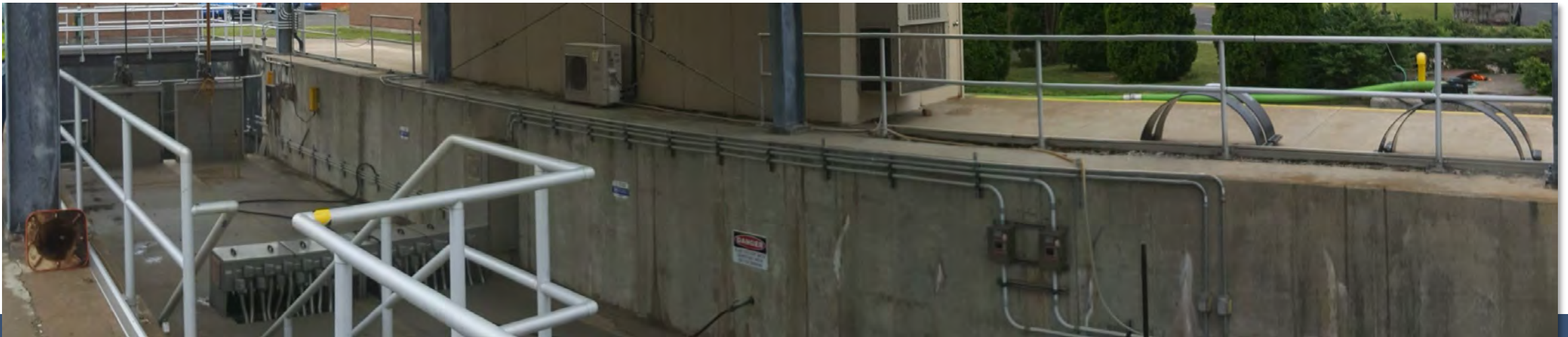
8.3.4.6 Reliability

A UV system must be capable of delivering the design dose and disinfecting effluent at peak instantaneous flows with one bank of modules out of service. For systems that require continuous, uninterrupted disinfection, more than one UV reactor (channel) is required.

A UV system also requires a backup electrical supply capable of powering the entire system. The electrical supply must be designed to prevent common-mode failure of an electrical component from disabling the entire disinfection system.

- Effectively requires a standby channel, or a standby lamp bank per channel

- Aging equipment
 - Original system installed under early 2000s plant upgrade
 - Occasional lamp shutdowns due to low water levels
 - Algae impacts
- NPDES permit limits
 - Stricter limits for fecal coliform and Enterococcus introduced in 2016



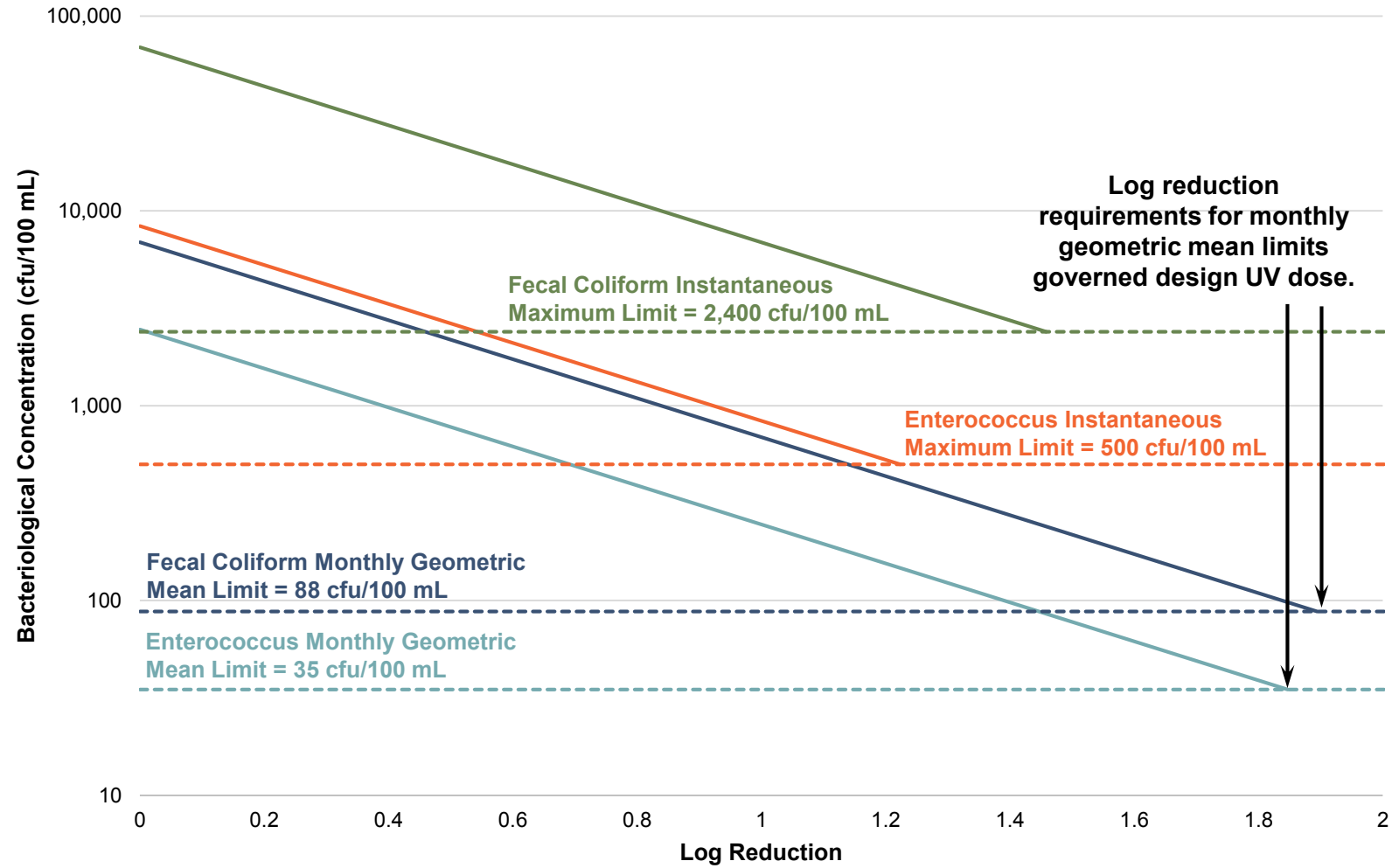
Field and Laboratory Sampling and Testing

Field Sampling

- Pre-UV sampling of fecal coliform and Enterococcus concentrations
 - Compare to NPDES permit limits
 - Determine log reductions that must be achieved by UV disinfection system

Parameter	Fecal Coliform by Membrane Filtration (cfu / 100 mL)	Fecal Coliform by Most Probable Number (MPN / 100 mL)	Enterococcus by Membrane Filtration (cfu / 100 mL)	Enterococcus by Most Probable Number (MPN / 100 mL)
No. of Samples	76	14	50	16
Geometric Mean	5,337	6,903	2,462	1,175
Maximum	69,000	41,060	8,364	7,209
	must reduce to 88 cfu / 100 mL	must reduce to 2,400 cfu / 100 mL	must reduce to 35 cfu / 100 mL	must reduce to 500 cfu / 100 mL

Pre-UV Bacteriological Log Reductions Required



— Fecal Coliform Instantaneous Maximum
 — Enterococcus Instantaneous Maximum
— Fecal Coliform Monthly Geometric Mean
 — Enterococcus Monthly Geometric Mean

Collimated Beam Testing

- Bench-scale laboratory test
 - Single lamp and small volume of water
 - Develop UV dose-response relationships
 - Establish target UV dose

$$UV \text{ Dose} \left(\frac{mW - sec}{cm^2} \text{ or } \frac{mJ}{cm^2} \right) = UV \text{ Light Intensity} \left(\frac{mW}{cm^2} \right) \times \text{Exposure Time}(sec)$$

- **Not directly equivalent to theoretical dose of operating UV systems or bioassay doses determined with test organisms**
 - *Average Intensity x Average Contact Time dose model for full-scale UV system*
 - *Attenuation factors: quartz sleeve transmittance, lamp aging, lamp fouling*
 - *Theoretical dose generally much higher than collimated beam dose*

Collimated Beam Testing Results

UV Dose (mJ/cm ²)	Fecal Coliform (cfu / 100 mL)	Enterococcus (cfu / 100 mL)
0	12,600	2,180
5	1,740	1,030
10	38	145
15	5	19
20	< 2	5
30	< 2	5
40	< 2	3

- Enterococcus reduction requires higher UV dose
 - 8 mJ/cm² per log reduction → 19 mJ/cm²
 - Minimum regulatory design dose of 30 mJ/cm²

Design Approach and Configuration

Alternative Channel Configurations



**Existing
UV Channels 1 and 2
in Basin 2**

Unused Basin 1

Alternative Channel Configurations

Alternative No.	Description	No. of Channels			Redundant Lamp Bank per Channel (Yes/No)
		Duty	Standby	Total	
1	Construct two (2) new channels in unused Basin 1; replace existing equipment in two (2) existing channels in Basin 2	3	1	4	No
2	Construct three (3) new channels in unused Basin 1	2	1	3	No
3	Construct three (3) new channels in unused Basin 1	3	0	3	Yes
4	Construct two (2) new channels in unused Basin 1 and one (1) new channel in Basin 2	3	0	3	Yes
5	Construct two (2) new channels in unused Basin 1	2	0	2	Yes
6	Construct one (1) new channel in unused Basin 1 and one (1) new channel in Basin 2	2	0	2	Yes

Lamp Configurations and Manufacturers Considered

Vertical Lamp Systems

- Ozonia Aquaray 3X
- Trojan UVSigna



Inclined Lamp Systems

- Wedeco Duron



Horizontal Lamp Systems

- Trojan UV3000Plus
- Wedeco TAK 55




Selected Channel Configuration

Alternative Channel Configuration	Advantages	Disadvantages
Alternative No. 1	<ul style="list-style-type: none"> • Standby channel at peak flow • Limited modifications to existing UV channels in Basin 2 	<ul style="list-style-type: none"> • Limited disinfection capacity during construction in Basin 2 • Channel operation during winter
Alternative No. 2	<ul style="list-style-type: none"> • Standby channel at peak flow • Full disinfection capacity during construction • Abandon existing UV channels in Basin 2 	<ul style="list-style-type: none"> • Insufficient basin width for egress • Insufficient channel wall width for weir gate mounting • Conflicts between adjacent power distribution centers • Infeasible for Wedeco Duron • Channel bends at north end
Alternative No. 3	<ul style="list-style-type: none"> • Full disinfection capacity during construction • Abandon existing UV channels in Basin 2 	<ul style="list-style-type: none"> • All channels in service at peak flow • Multiple banks in series • Limited basin width for egress • Limited channel wall width for weir gate mounting • Conflicts between adjacent power distribution centers • Channel bends at north end
Alternative No. 4	<ul style="list-style-type: none"> • Improved access and working space versus Alternative No. 2 • Improved channel hydraulics versus Alternative No. 2 	<ul style="list-style-type: none"> • Limited disinfection capacity during construction in Basin 2 • Multiple banks in series
Alternative No. 5	<ul style="list-style-type: none"> • Full disinfection capacity during construction • Abandon existing UV channels in Basin 2 	<ul style="list-style-type: none"> • All channels in service at peak flow • Multiple banks in series • Infeasible for Wedeco Duron • Wide channel spans
Alternative No. 6	<ul style="list-style-type: none"> • Superior layout to Alternative No. 4 	<ul style="list-style-type: none"> • Limited disinfection capacity during construction in Basin 2 • All channels in service at peak flow • Multiple banks in series • Wide channel spans

Pre-Selection of UV Disinfection Equipment

- Request for proposals (RFP) for pre-selection of new UV disinfection system equipment
- Evaluation criteria
 - Equipment features
 - Installed equipment experience
 - Preventive maintenance and service and parts availability
 - Equipment cost
 - O&M life-cycle cost
- Proposals received
 - Trojan UV3000Plus
 - Wedeco Duron

MAYOR
DAVID R. MARTIN



PURCHASING AGENT
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CITY OF STAMFORD
OFFICE OF ADMINISTRATION
888 WASHINGTON BOULEVARD
STAMFORD, CT 06904-2152

REQUEST FOR PROPOSALS No. 732

**ULTRA-VIOLET DISINFECTION SYSTEM
FOR
STAMFORD WATER POLLUTION CONTROL AUTHORITY**

PROPOSALS DUE: FEBRUARY 7, 2018 @ 4:00 P.M.

SUBMIT TO: CITY OF STAMFORD
888 WASHINGTON BOULEVARD
STAMFORD, CT 06904-2152

ATTENTION: ERIK J. LARSON
AT (203) 977-4107 OR
elarson@stamfordct.gov

RFP BOND: 5%

NUMBER OF COPIES REQUIRED:
ONE ORIGINAL AND TWELVE (12)
COPIES, ALONG WITH TWO (2)
ELECTRONIC VERSIONS (USB
DRIVE)

NOTE THE FOLLOWING: ALL PROPOSAL SPECIFICATIONS AND DOCUMENTS CAN BE PICKED UP DIRECTLY FROM COUNTY REPRODUCTIONS, INC., LOCATED AT 39 BELDEN STREET, STAMFORD, CT 06902. TELEPHONE (203) 348-3758. A NON-REFUNDABLE FEE WILL BE CHARGED FOR THESE DOCUMENTS.

Date Issued: 1/9/2018
(REV: 09-01-17)

Pre-Selected UV Disinfection Equipment

Design Parameter/Characteristic	Value
Lamp Orientation	Horizontal
Water Depth at Upstream Lamp Bank (in)	35.16
Input Power per Lamp (W)	240
Lifting Device	External bridge crane
Wiper Drive Type	Hydraulic
Lamp Sleeve Cleaning	Mechanical & chemical
Number of Channels	3
UV Lamp Banks per Channel	3 (2 Duty, 1 Standby)
Total No. of UV Lamps	936
Total Power (kW)	236
Guaranteed Power at 24 mgd and 67% UVT (kW)	46
UV Dose at Design Conditions (mJ/cm ²)	36.9
Head loss at Peak Flow (in)	4.48
Minimum Weir Length per UV Channel (in)	81.00



CITY OF STAMFORD, CONNECTICUT
STAMFORD WATER POLLUTION CONTROL AUTHORITY
 UV DISINFECTION SYSTEM UPGRADE AND REPLACEMENT
 ULTRAVIOLET DISINFECTION EQUIPMENT

REQUEST FOR PROPOSAL No. 732



SUBMITTED BY TROJAN TECHNOLOGIES

Steve Payler, Trojan Technologies - spayler@trojanuv.com – 519.457.3400

AND OUR LOCAL REPRESENTATIVES

Fred Croy, The Maher Corporation - fcroy@themaher.copr.com – 781.421.2600

PROPOSAL DUE: FEBRUARY 7, 2018, @ 4:00 P.M.



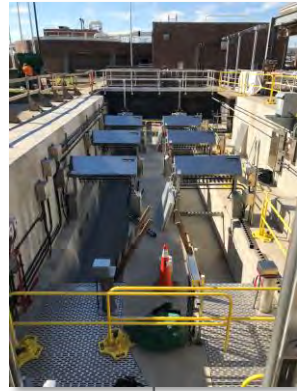
Construction Sequencing and System Commissioning

Construction Sequencing



Phase 1

- Continue operating existing UV channels in Basin 2



Commissioning

- Functional testing
- Intensive performance testing
 - Head loss
 - Power demands
 - Effluent quality
- Automatic control performance testing
 - 30 days
 - Daily sampling



Phase 2

- Operate new UV Channels 1 and 2 in Basin 1
- Continue operating one existing UV channel in Basin 2



Phase 3

- Operate new UV Channels 1-3 in Basins 1 and 2



Phase 4

- Prepare remaining channel in Basin 2 for future UV disinfection equipment

Phase 1 Commissioning

UV Channel Flow Measurement

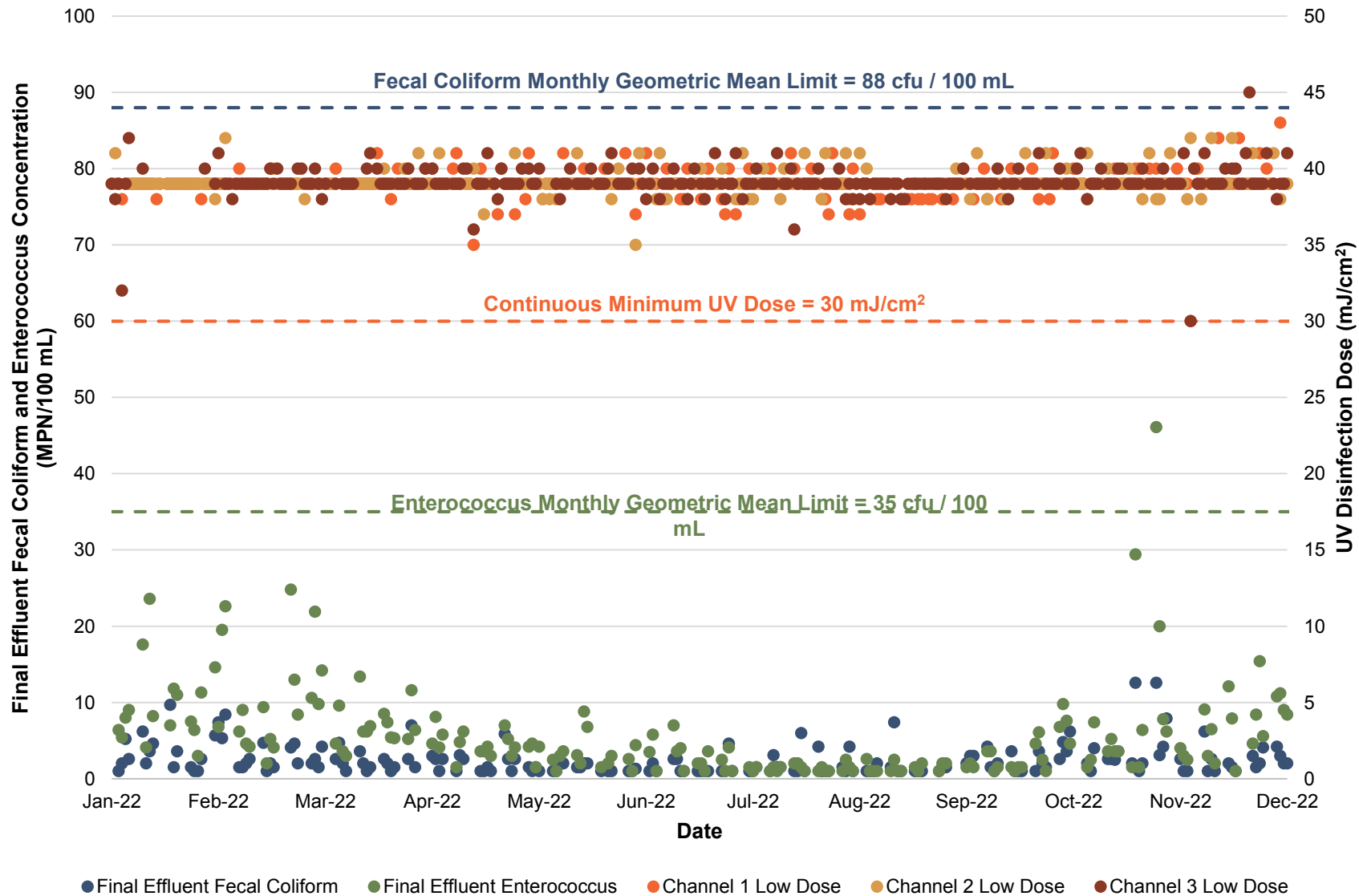


Directly measure flow over UV channel effluent weir gates



Compare channel water depth to effluent weir gate position

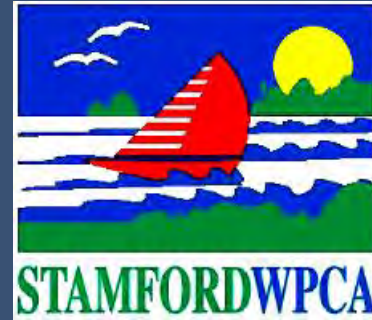
UV Disinfection Performance



Questions?

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Hazen