



SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Wastewater Operator Training Series

Session 16: Disinfection Part 2 – Chlorination Chemistry, and Alternative Disinfection Methods

10/8/2026

Your trainers for today:



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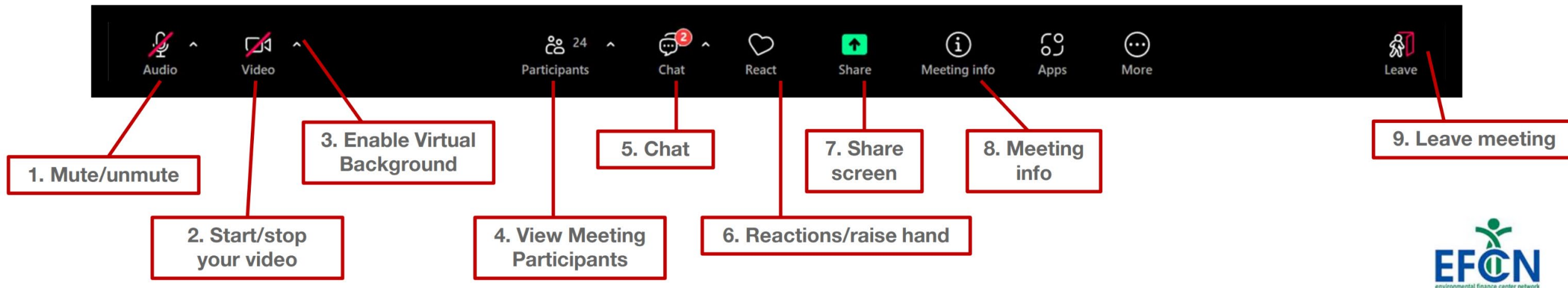
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This training series is funded by the EPA

Attendee Meeting Controls

- Locate your control bar
- All attendees will see a black horizontal bar on their screen
- If your control bar is not visible, it may be hidden
 - Move your cursor to the screen's bottom (or top) to reveal this control bar.



WPI/ABC Operator Certification

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Q Search ...

Standardized Wastewater Treatment Operator Exams

Wastewater Treatment Operator Need-to-Know Criteria

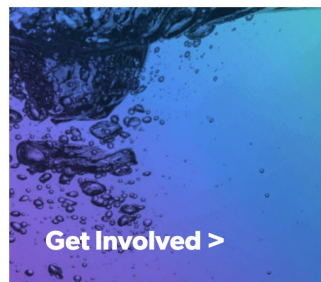
Need-to-Know Criteria outline the content that will be covered on WPI's standardized examinations provided through [ABC Testing](#), a WPI service.

- [Wastewater Treatment Operator Class I](#)
- [Wastewater Treatment Operator Class II](#)
- [Wastewater Treatment Operator Class III](#)
- [Wastewater Treatment Operator Class IV](#)

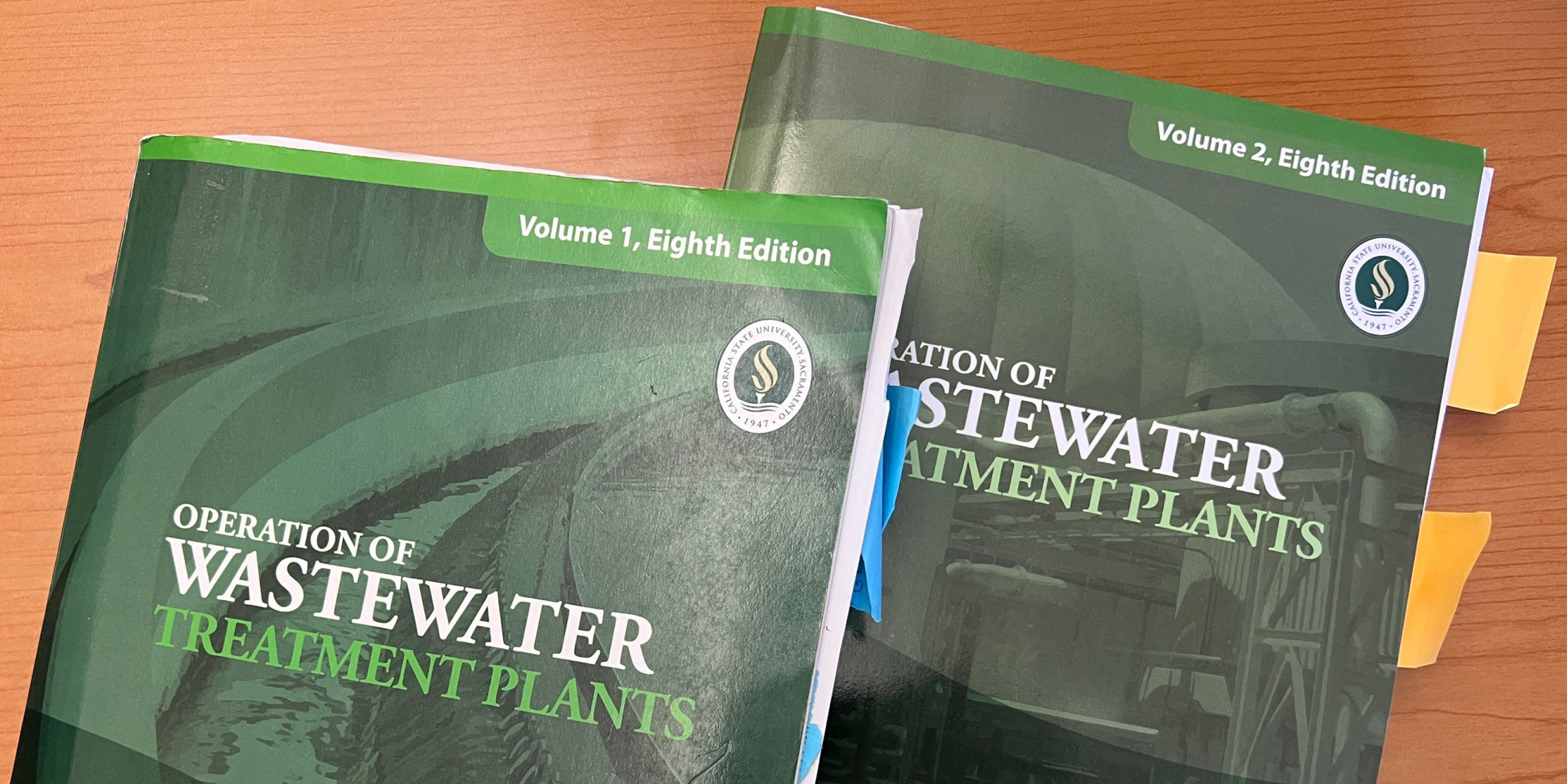
Wastewater Treatment Operator Formula/Conversion Table

WPI standardized exams are administered with a Formula/Conversion Table containing mathematical formulas and common abbreviations that may be present on the exam.

- [Wastewater Treatment Operator Formula/Conversion Table](#)



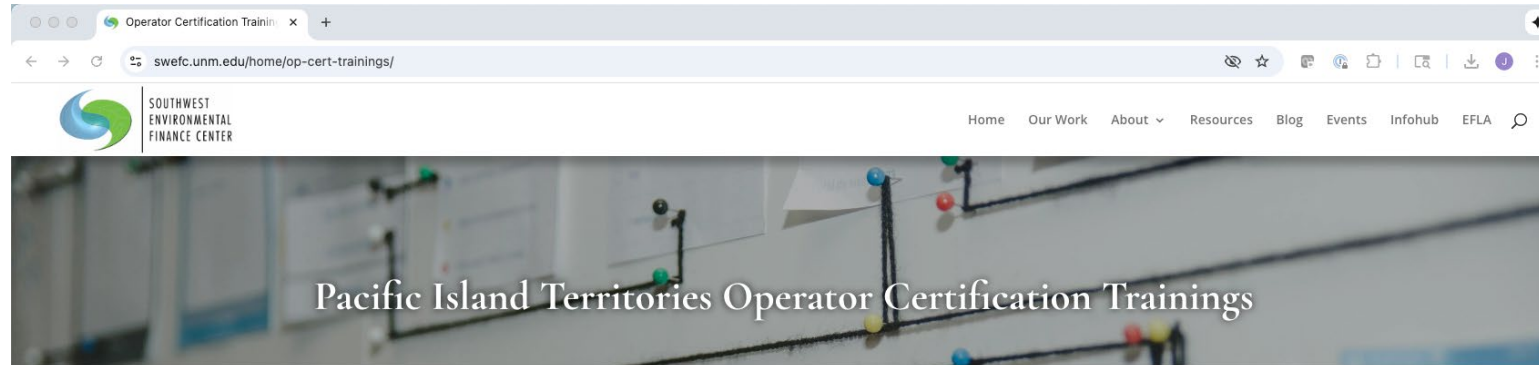
Use all your resources



Schedule for 2025:

Date	Topic
1/20/26	Concept and Math Review Session
2/3/26	Disinfection Part 1 (chlorination/dechlorination) + related math
2/17/26	Disinfection Part 2 - UV and other methods
3/3/26	WW Math Part 3 (Flow, Detention Time)
3/17/26	WW Math Part 4 (BOD Math /Advanced WW Math)
3/31/26	Solids Handling Part 1 (Mechanical Solids Separation)
4/14/26	Solids Handling Part 2 (Solids Handling)
4/28/26	Sampling
5/12/26	Regulations (NPDES Permits and Discharge Limitations)
5/26/26	Treatment System Maintenance
6/9/26	Lab Procedures/Analysis/Interpretation or alternate topic
6/23/26	Using Technology in daily operations (SCADA, Computer, Tablets, CMMS, AI, etc.)
7/7/26	Course Review Session - Short sample exam?

<https://swefc.unm.edu/home/op-cert-trainings/>



This page is a repository of Wastewater and Drinking Water Operator Certification (Op Cert) Training Webinars offered by the SW EFC for systems in the Pacific Territories. Below you will find the **training webinar schedules (wastewater, then drinking water)** followed by a **training webinar recordings library**.

[Jump to Wastewater Trainings](#)[Jump to Drinking Water Trainings](#)

Wastewater Training Schedule

Please note all times are local to CNMI and Guam. The times in American Samoa are one day earlier at 11 am.

Session	Date	Training Topic & Link to Recording (click to view)	Supporting Materials (click to download)
1	6/25/2025	Program Overview, Test Format, Study & Test Tips	PPT slides
2	7/9/2025	Treatment Overview	PPT slides
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	PPT slides
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	PPT slides
5	8/20/2025	Collection Systems – Gravity systems	PPT Slides
6	9/3/2025	Collection Systems – Pumping & Force Mains	PPT Slides
			Collection Systems (Grades 1 – 2) Course #401
			Tech Brief – Reading Centrifugal Pump Curves
			Grundfos E-cademy – Pump Selection Basics
7	9/17/2025	Collection System Maintenance	Pennsylvania Department of Environmental Protection Module 9: Basics of Pumps and Hydraulics
			PPT Slides
			PPT Slides
8	10/1/2025	Operator Safety/OSHA/Chemical Safety & Inventory	PPT Slides
9	10/15/2025	Preliminary Treatment	PPT Slides
10	10/29/2025	Primary Treatment: Sedimentation	

Sign in for every session to ensure you get credit for attending



**US Territories Water & Wastewater Operator Certification
Virtual Training Series Group Attendance Sheet**

Session Title: _____
Session Date: _____
Training Location: _____

Attendee Name	Attendee Signature	Arrival Time	Departure Time

I hereby certify that the individuals listed above attended the referenced training session.

Name: _____
Signature: _____
Title: _____
Date: _____

Overview

- Advanced Chlorine Chemistry
- Chlorine Calculations
- Alternative Methods of Disinfection
- Alternative Methods Safety

Chlorine Chemistry

Benefits of understanding chlorination chemistry

- Process Control
- Disinfection Efficiency
- Permit Compliance
- Safety
- Cost
- Common Certification Topic



Chlorine Variations

Free Chlorine

- Hypochlorous acid and hydrochloric acid
- Strong disinfectants

Combined Chlorine-Chloramines

- Form from hypochlorous acid in the presence of Ammonia (NH_3)
- Chloramines are often created intentionally due to their enduring properties
- Monochloramines, dichloramines, and trichloramines



Chloramine

Monochloramines $NH_3 + HOCl \rightarrow NH_2Cl + H_2O$

- Weakest disinfectant

Dichloramines $NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$

Trichloramines $NHCl_2 + HOCl \rightarrow NCl_3 + H_2O$

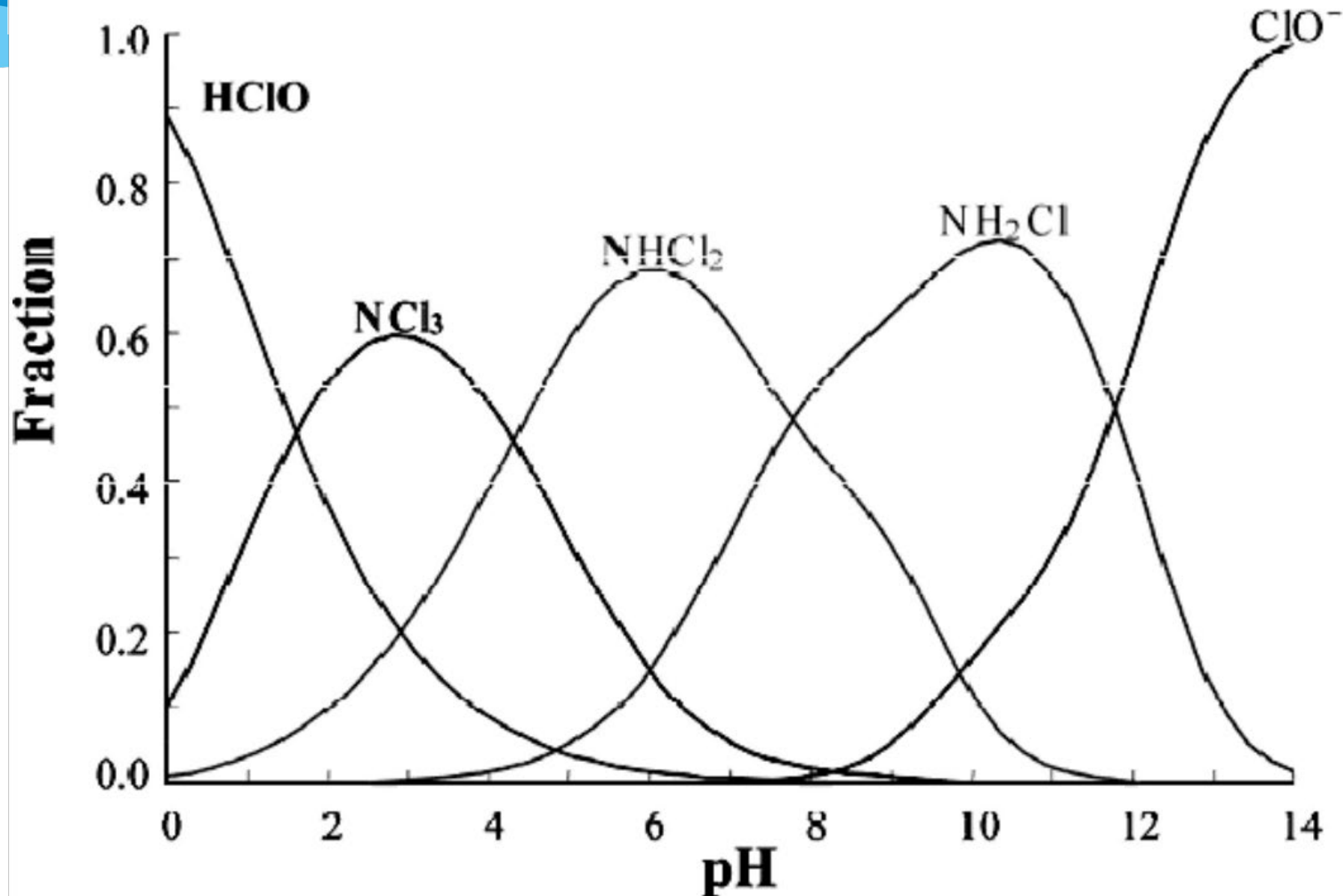
- Stronger disinfectant

Chloramines and pH

pH
determines
the
concentration
of the
different types

- Below pH = 4.0 trichloramines exist by themselves
- At pH= 4.0-5.5 dichloramine is the dominant form
- Both monochloramines and dichloramines exist at the pH of 6.5-7.5 of typical wastewater flows

Chloramines as a function of pH



Chlorine Residual Sampling

Sampling and Analysis used to determine chlorine components

- Indicates effectiveness of disinfection and compliance

Conducted as compliance and process sampling

- Compliance sampling determined by discharge permit
- Process samples typically taken post-chlorination or after dechlorination

Sampling should be consistent and standardized

Chlorine Analysis

Chlorine Residuals often detected with a DPD test

- Must be tested within 15 minutes of sampling
- Reagent is added and compared to the blank with a colorimeter or a color
- Can test for free or total chlorine

Combined Chlorine = Total Chlorine – Free Chlorine



Chlorine Sampling Sample Point

Sample point should provide representative sample

- Samples should be taken mid-stream, mid-depth
- Well-mixed flow
- Upstream of turbulent areas
- At the end of contact/mixing channels

Safety must be considered

- Utilize handrails, sample ports, and effluent taps when available
- Avoid leaning over ledges, confined spaces and slippery surfaces



Chlorine Sampling Procedures

Standard operating procedures should outline sample collection, analysis, documentation and reporting
Utilize personal protective equipment

Sample procedure basics

- Utilize clean sample bottles
- Rinse sample bottle with three times
- Transfer collected sample to sample vial
- Add free or total chlorine reagent within expiration date
- Fill lab analyzed samples completely and cap
- Follow blank procedure
- Document date and time, sample location, instrument ID, unusual conditions etc.





Poll Question 1



Poll Question 2

Chlorine Dosage

Chlorine applied to wastewater for treatment

- A concentration represented as a mass/volume
- Expressed as mg/L or ppm
- Most operators record pounds or gallons per day. This is the FEED RATE, not the dosage.
 - Dosage calculated from feed rate

$$\text{DOSAGE} = \text{RESIDUAL} + \text{DEMAND}$$

Chlorine Residual

- The amount of chlorine remaining after the chlorine demand is satisfied (expressed as mg/L)
- Total residual chlorine used as residual
- This chlorine **IS** available for further disinfection

$$\text{RESIDUAL} = \text{DOSAGE} - \text{DEMAND}$$

Chlorine Demand

- The difference between the amount of chlorine applied and the residual chlorine remaining
- The amount of chlorine consumed or bound up by material in the water (expressed as mg/L)
- This chlorine is **NOT** available as residual (free or total)

$$\text{DEMAND} = \text{DOSAGE} - \text{RESIDUAL}$$

Dosage Practice Problem

$$\text{Chlorine Dosage} = \text{Chlorine Demand} + \text{Chlorine Residual}$$

Determine the chlorine demand of a treated wastewater effluent if the chlorine dosage used for disinfection is 8 mg/L and the measured chlorine residual is 1.3 mg/L.

$$\text{Chlorine Dosage} - \text{Chlorine Residual} = \text{Chlorine Demand}$$

$$8 \frac{\text{mg}}{\text{L}} - 1.3 \frac{\text{mg}}{\text{L}} = 6.7 \frac{\text{mg}}{\text{L}}$$

A. 67 mg/L

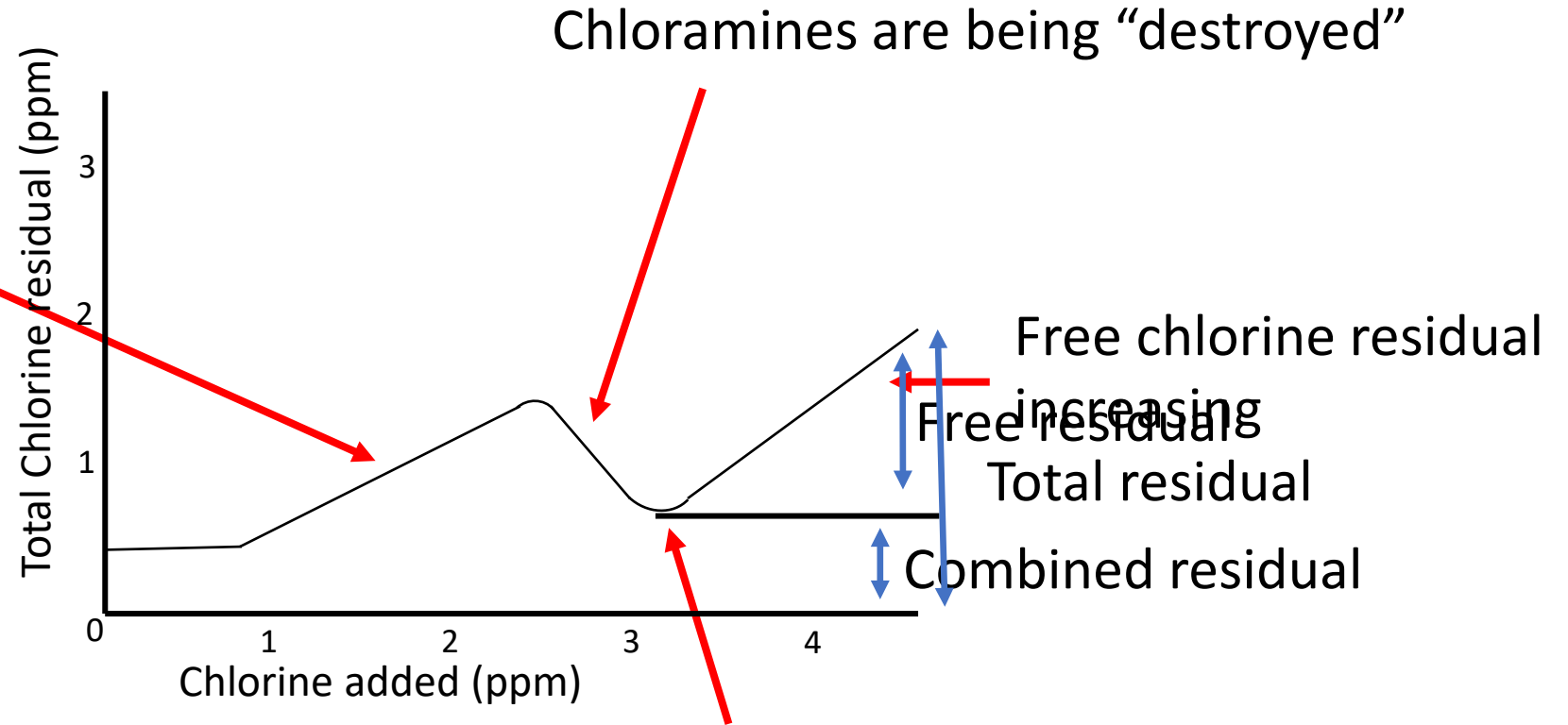
B. 9.3 lbs/day Demand

C. 6.7 mg/L

D. 9.3 mg/L

Breakpoint Chlorination

Chloramines formed
(combined chlorine
residual)



Breakpoint – Chlorine demand
of wastewater satisfied

Dosing Calculator

Calculating Chlorine Feed Rate						
Equation 1	Flow (MGD)	Desired Chlorine Dosage (mg/L)	Chlorine Strength (%)*	Chlorine Feed (lbs/day)		
	2	10	100%	166.8		
Input your average flow rate in millions of gallons per day (MGD), desired chlorine dosage (mg/L), and chlorine solution strength (%) to calculate the required chlorine feed rate (lbs/day) needed to achieve this dosage, which is highlighted in purple. *Chlorine strength will be 100% for gas, 12-15% for liquid hypochlorite, and 65-75% for granular/ tablet chlorine.						

Calculating Required Chlorine Dosage						
Equation 2	Flow (MGD)	Desired Chlorine Residual (mg/L)	Chlorine Strength (%)*	Typical Chlorine Demand (mg/L)	Required Chlorine Dosage (mg/L)	Required Chlorine Feed (lbs/day)
	2	0.1	100%	8	8.1	135.108
Input your average flow rate (MGD), desired chlorine residual (mg/L), chlorine solution strength (%), and typical chlorine demand (mg/L), to calculate your required chlorine dosage (mg/L) and required chlorine feed rate (lbs/day), which are highlighted in purple. The chlorine residual should be determined by your NPDES permit or other regulatory requirements. The typical chlorine demand is determined by troubleshooting and usually ranges between 5-20 mg/L for wastewater after biological treatment. *Chlorine strength will be 100% for gas, 12-15% for liquid hypochlorite, and 65-75% for granular/ tablet chlorine.						

Chlorine Residual						
Equation 3	Flow (MGD)	Chlorine Feed (lbs/day)	Chlorine Strength (%)*	Chlorine Demand (mg/L)	Chlorine Dosage (mg/L)	Chlorine Residual (mg/L)
	2	125.00	100%	7	7.49	0.49
Input your average flow rate (MGD), chlorine feed rate (lbs/day), chlorine solution strength (%), and typical chlorine demand (mg/L), to calculate your corresponding chlorine dosage (mg/L) and required chlorine residual (lbs/day), which is highlighted in purple. The typical chlorine demand is determined by troubleshooting and usually ranges between 5-20 mg/L for wastewater after biological treatment. *Chlorine strength will be 100% for gas, 12-15% for liquid hypochlorite, and 65-75% for granular/ tablet chlorine.						

Chlorine Feed Rate Calculations

$$\text{Chlorine feed rate}(\underline{\text{lbs/day}}) = \frac{\text{flow}(\cancel{\text{MGD}}) \times \text{dosage}(\cancel{\text{mg/L}}) \times 8.34(\cancel{\text{lbs/gal}})}{\text{Cl solution strength (decimal)}}$$

$$\text{Cl}_{\text{dosage}} (\text{mg/L}) = \frac{\text{Cl}_{\text{feed}} (\text{lbs/day}) \times \text{Cl solution strength (decimal)}}{Q (\text{MGD}) \times 8.34 \left(\frac{\text{lbs}}{\text{gal}}\right)}$$

*Liquid hypochlorite 12-15% and HTH 65-75%



Poll Question 3

Alternative Disinfection Methods

UV, Ozone, Filtration, Wetlands

UV Disinfection

Uses UV radiation to sterilize microorganisms

- Without the ability to reproduce microbes cannot cause disease

Example of physical disinfection

Wastewater is exposed to UV radiation in the UV reactor

Treatment relies on UV dosage

$$\text{UV dose} = \text{UV Intensity} \times \text{Time}$$



UV Radiation

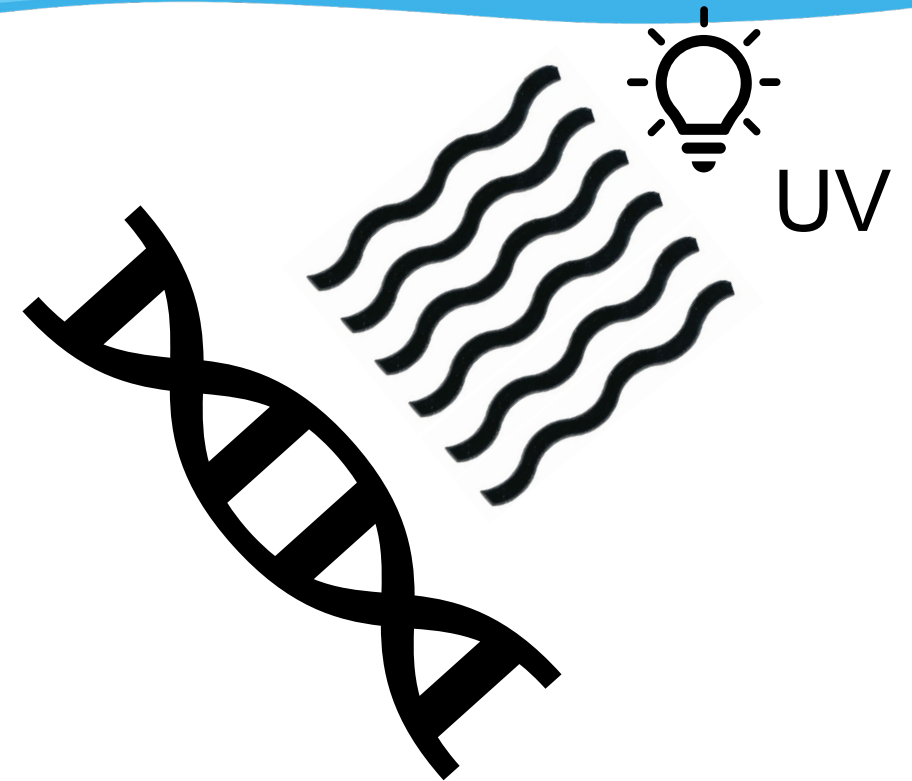
Wastewater is exposed to UV radiation by banks of long tubular UV lamps filled with mercury vapor

- Water flows in line with UV lamps

Ultraviolet (UV) lightbulbs emit a specific range of wavelengths of light that damage microbe DNA to prevent replication

200-300 nm is the germicidal range

- 264 nm specifically kills microbes most effectively



UV Disinfection Components

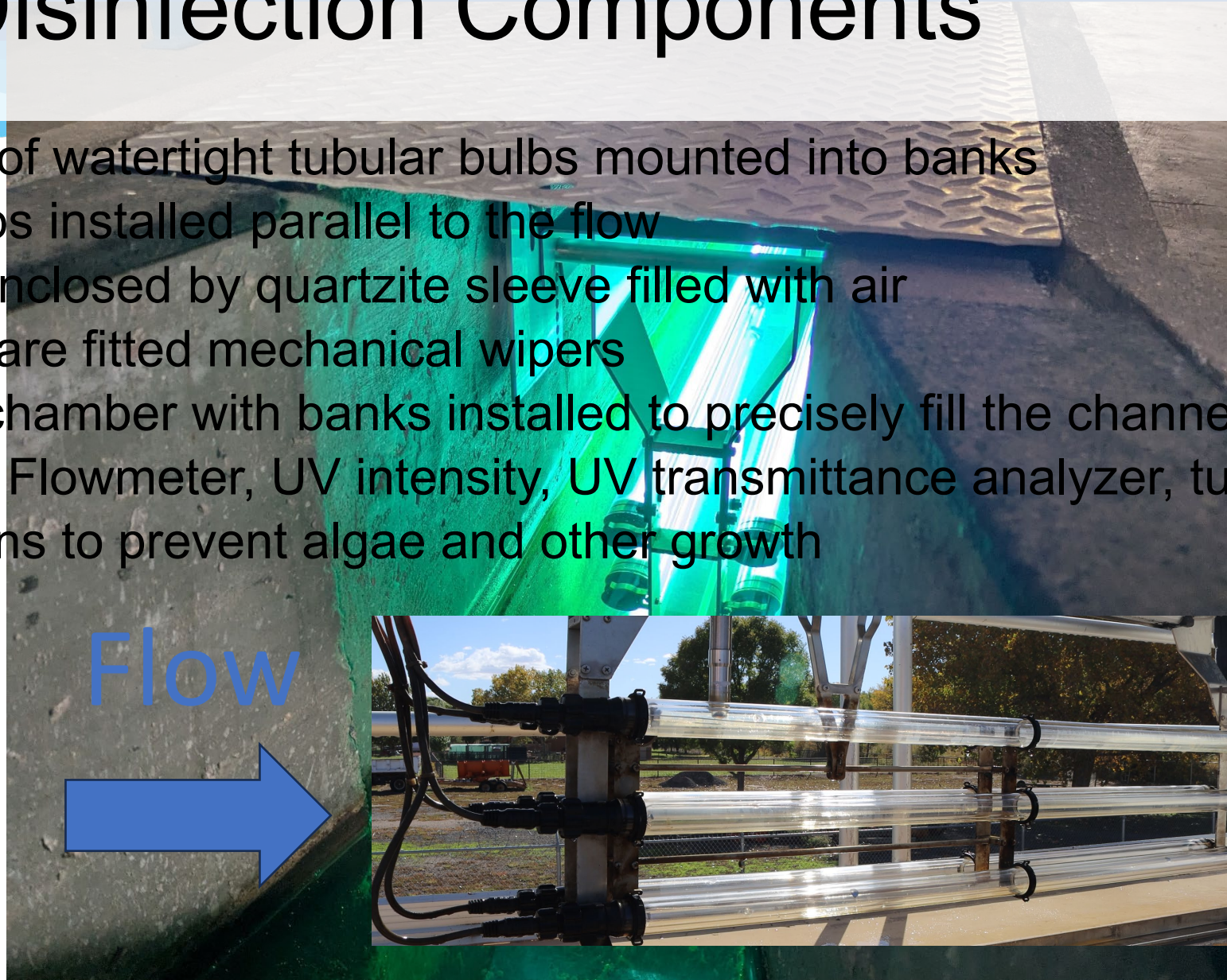
Modules of watertight tubular bulbs mounted into banks

- UV bulbs installed parallel to the flow
- Lamp enclosed by quartzite sleeve filled with air
- Lamps are fitted mechanical wipers

Contact chamber with banks installed to precisely fill the channel

Sensors- Flowmeter, UV intensity, UV transmittance analyzer, turbidity meter

Prescreens to prevent algae and other growth



UV Disinfection Process Control

Operation of UV Disinfection includes the following

- Monitoring and managing the UV dose
- Cleaning UV tubes
- Monitoring equipment performance and performing maintenance
- Cleaning pre-screens

UV systems are designed to treat a specific volume of water

Treatment is measured by the designed UV intensity or determined UV dosage

Adjustments to UV intensity, the number of modules used for treatment, or to the flow are used to adjust UV operation

Flow level should always be right above the top UV bulb

UV Disinfection Operation Check List

Visually inspect reactor

Confirm controls are in auto and check for alarms

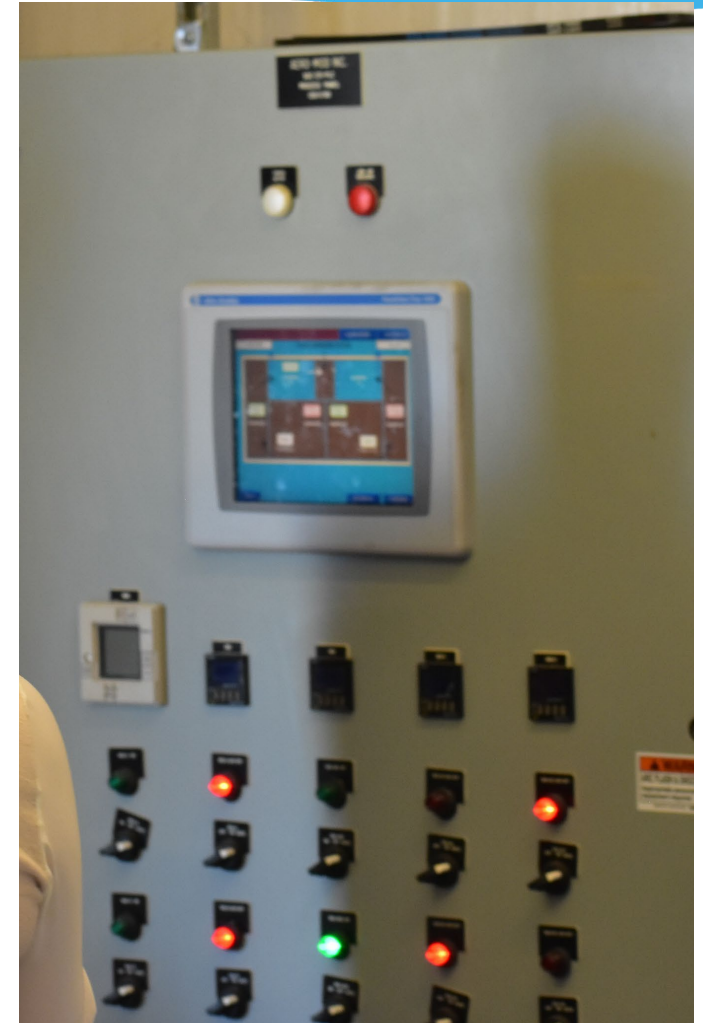
Check sensors, flow meters, and data records

➤ Use data logs to verify

Periodically initiate manual wiper sequence

Check UV light run times

Calibrate sensors periodically



Ultraviolet (UV) Light Disinfection

Advantages of UV Disinfection	Disadvantages of UV Disinfection
No need to handle chemicals	Tubes can foul
No residual	High interference from turbidity
User friendly for operator	Higher cost than chlorine
Low contact time needed	Organisms can sometimes repair the damage from UV radiation
Low space requirement	

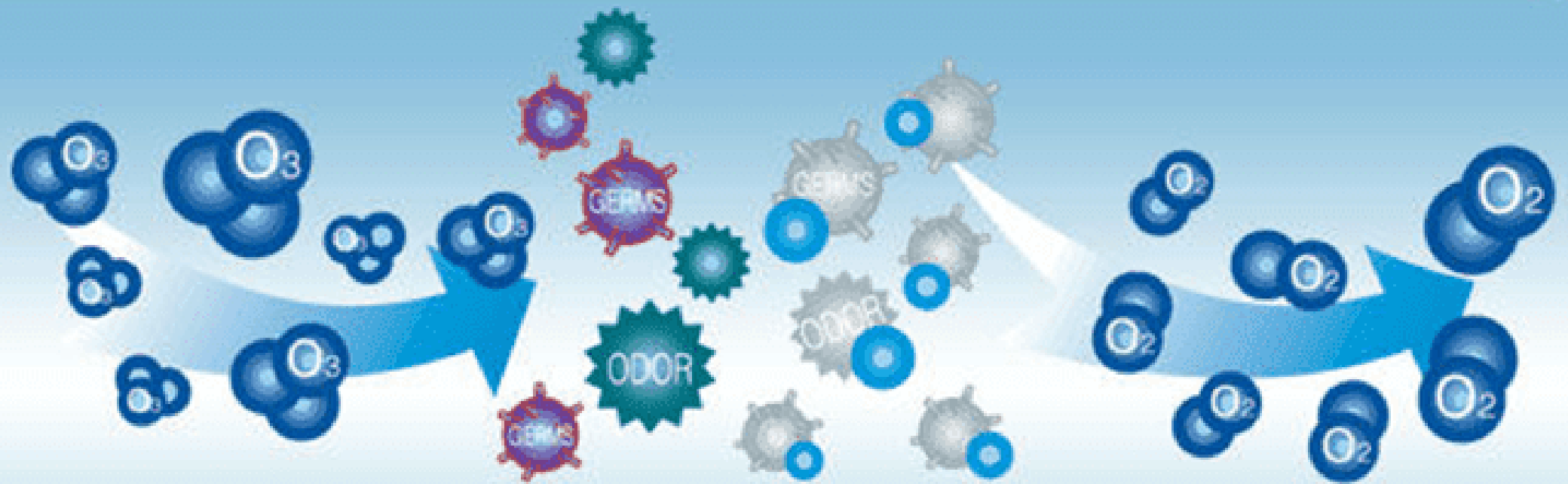
UV Safety

UV Hazards

- UV radiation is intense and much stronger than visible light
 - Avoid looking directly at UV lightbulbs
 - Do not expose your skin to UV light
- Ensure hazard signs are present in the UV areas
- Power off lights when handling UV lights
- UV lamps contain mercury vapor



Ozone



Active ozone



Sanitize odor and germs



Fresh oxygen

Ozone Process and Safety

Ozone generated and injected into the contact chamber where it mixes with the treated wastewater

- Plug-flow type reactor
- Contact time typically 10-20 min
- Process is automated

Ozone monitors should be installed near ozone generators, ozone reactors, and distribution lines

Be aware of ozone sickness symptoms

Ozone

Advantages

- More effective than chlorine in destroying bacteria and viruses
- Short contact time
- No harmful residuals
- No shipping hazards due to onsite production
- Bacteria will not grow back unless shielded by molecules

Disadvantages

- Low doses may not be effective enough
- Technology is very complex and can be dangerous

Alternative Methods of Disinfection

Filtration

- Microfiltration (0.1-10 μm): Bacteria and protozoa
- Ultrafiltration (0.01-0.1 μm): Bacteria, protozoa, and some viruses
- Nanofiltration (0.001-0.01 μm): Bacteria, protozoa, and most viruses
- Reverse Osmosis (<0.001 μm): Virtually all pathogens
- Sand Filtration: Some pathogens

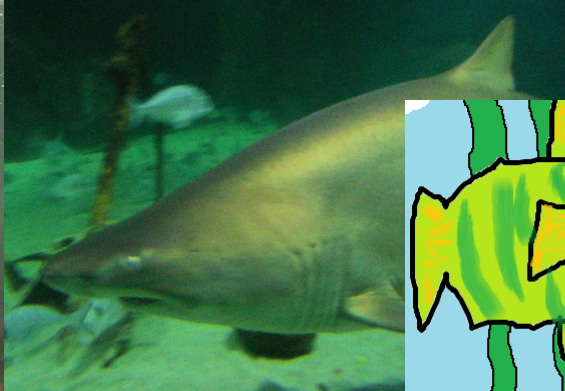
Constructed Wetlands

- Natural microbial ecology results in the removal of pathogens



Poll Question 4

Thank you for attending and for protecting aquatic life and water for downstream consumption!





Questions?

CONTACT INFORMATION



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