

# Overview of DBP Formation & Control Strategies

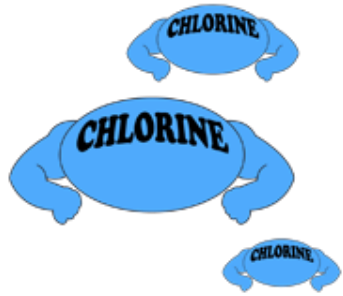
Stephen C. Olson, P.E.

President, H2Olson Engineering, Inc.

October 8, 2025

# What are DBPs and How are they Formed?

## Free Chlorine (Cl<sub>2</sub>)

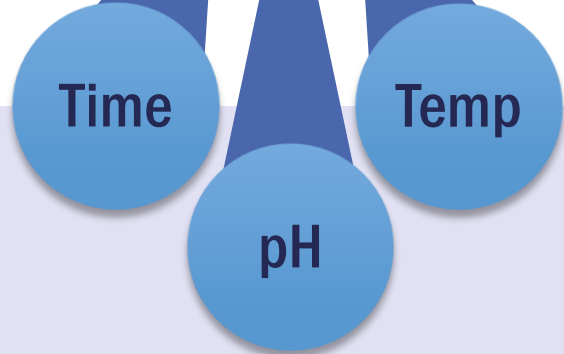


Chlorine Gas  
Sodium Hypochlorite  
Calcium Hypochlorite  
Bleach

## Natural Organic Matter (NOM)

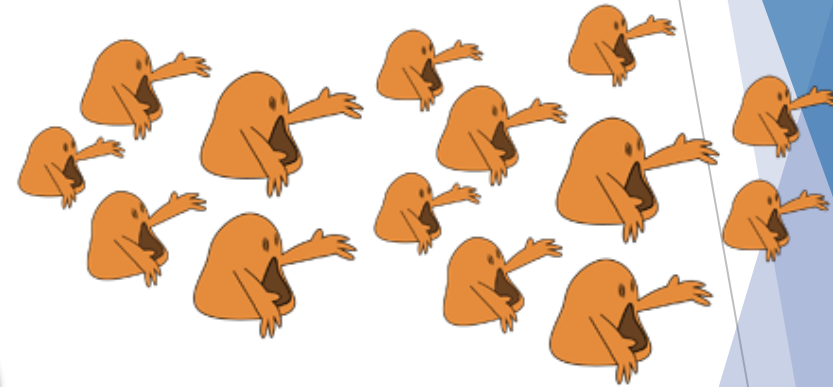


TOC/DOC  
Aquatic Humics  
Algal Matter



Factors Contributing to Higher DBP Formation

## Disinfection Byproducts (DBP's)



### Trihalomethanes

Chloroform  
Bromoform  
Bromodichloromethane  
Dibromochloromethane

### Haloacetic Acids

Chloroacetic Acid  
Bromoacetic Acid  
Dichloroacetic Acid  
Dibromoacetic Acid  
Trichloroacetic Acid

### Maximum Contaminant Level

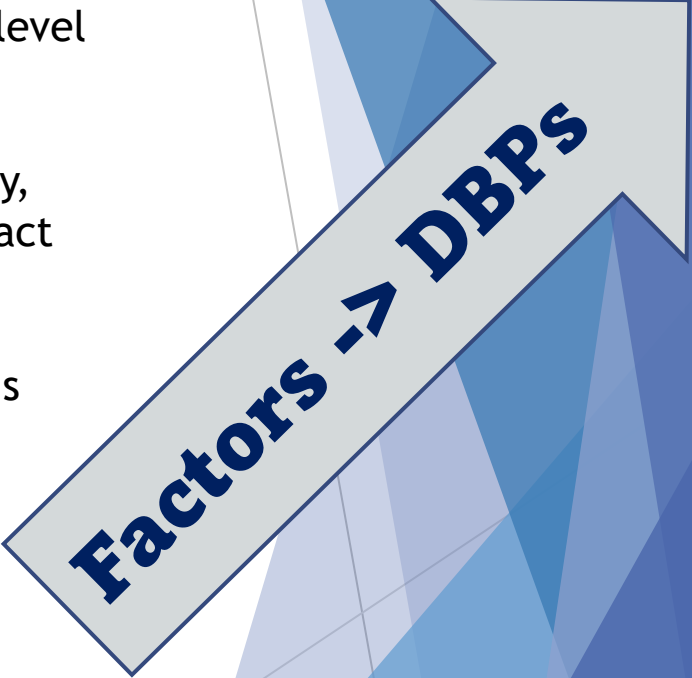
80 µg/L

60 µg/L

based on locational running annual average (LRAA) of quarterly sampling events.

# Factors Affecting the Formation of DBPs

1. **Chlorine Dose** - One of the 2 Key Ingredients forming DBPs. Generally, higher concentrations of chlorine will result in the formation of greater levels of DBPs.
2. **Natural Organic Matter** - The other Key Ingredient. Some types of NOM are more reactive with chlorine than others (DBP precursors). So, by limiting/reducing the level of reactive NOM before the addition of chlorine can minimize DBPs.
3. **Time** - the reaction between chlorine and NOM to form DBPs takes time. Generally, DBPs will increase with increasing reaction time (the more time chlorine has to react with NOM, the more DBPs will be produced).
4. **pH** - like many other chemical reactions, the reaction between chlorine and NOM is affected by pH. Generally, the formation of DBPs increases with greater water pH levels.
5. **Temperature** - water temperature affects the kinetics of the chemical reaction between chlorine and NOM. Generally, DBP levels will increase with increasing temperature. Distribution system DBP levels are typically higher in warm summer months than in cold winter months.

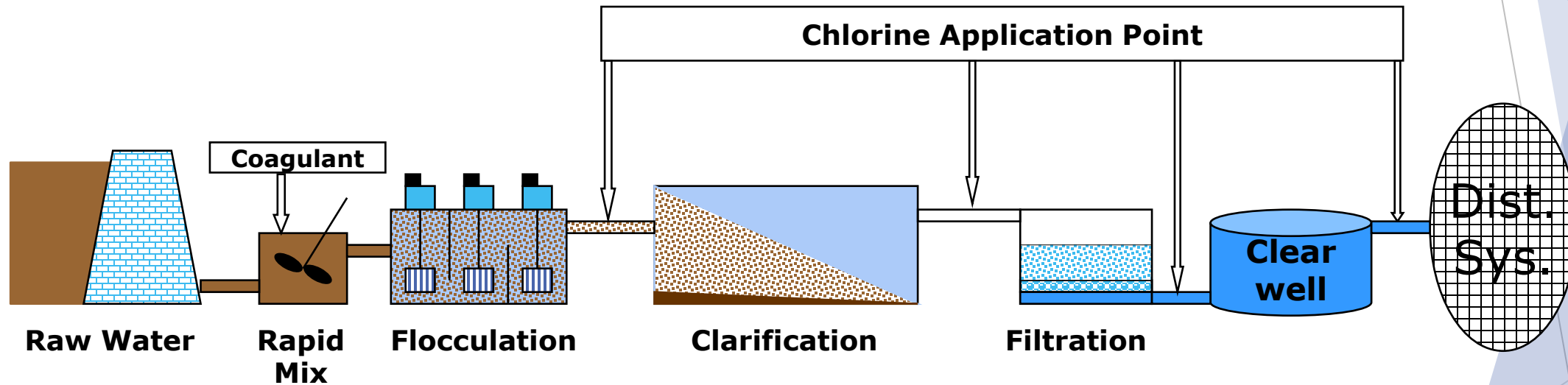


**Factors -> DBPs**

# DBP Control Strategies

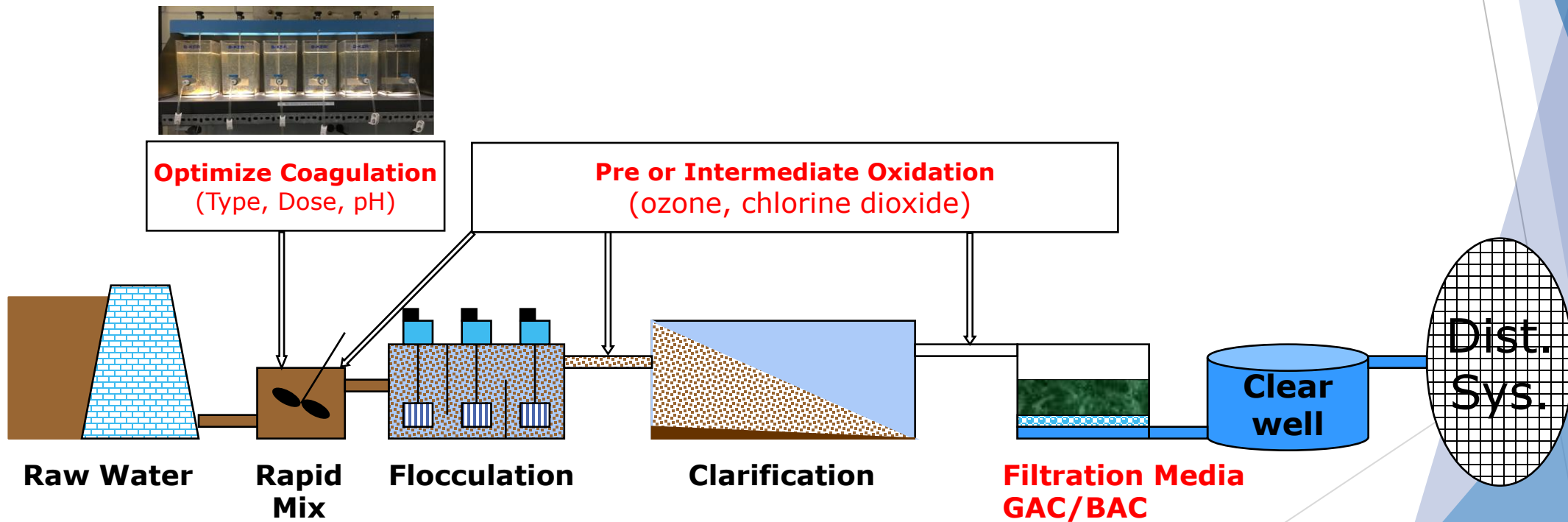
## 1. Modify Chlorine Disinfection

- Change the application point
- Lower the chlorine dose



# DBP Control Strategies (cont.)

2. Remove/Reduce/Modify the level Natural Organic Matter
  - Optimize Coagulation
  - Pre/Intermediate Oxidation (Ozone, Chlorine Dioxide)
  - GAC/BAC

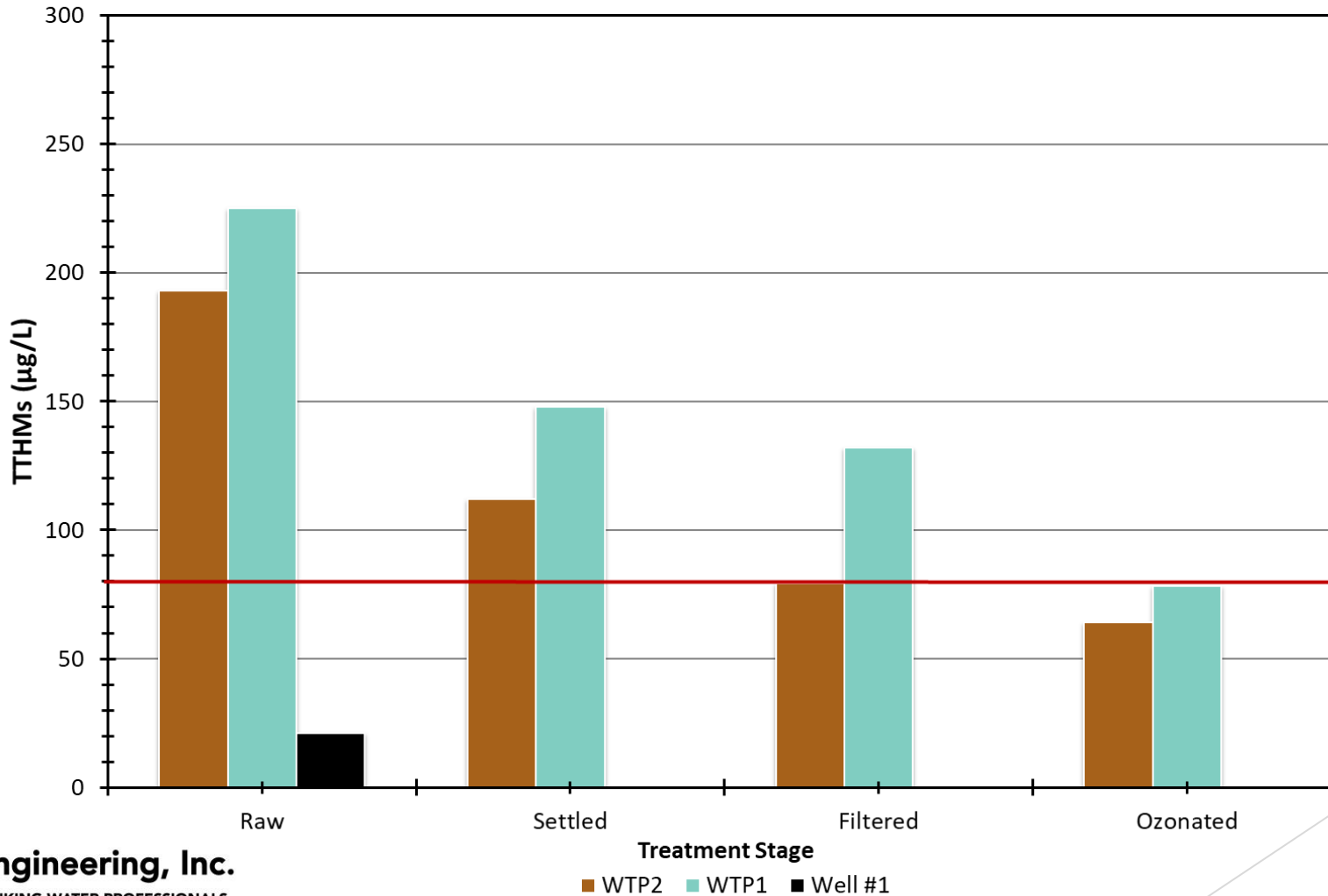


# DBP Control Strategies (cont.)

## 2. Remove/Reduce/Modify the level Natural Organic Matter

### ➤ Pre/Intermediate Oxidation - Ozone

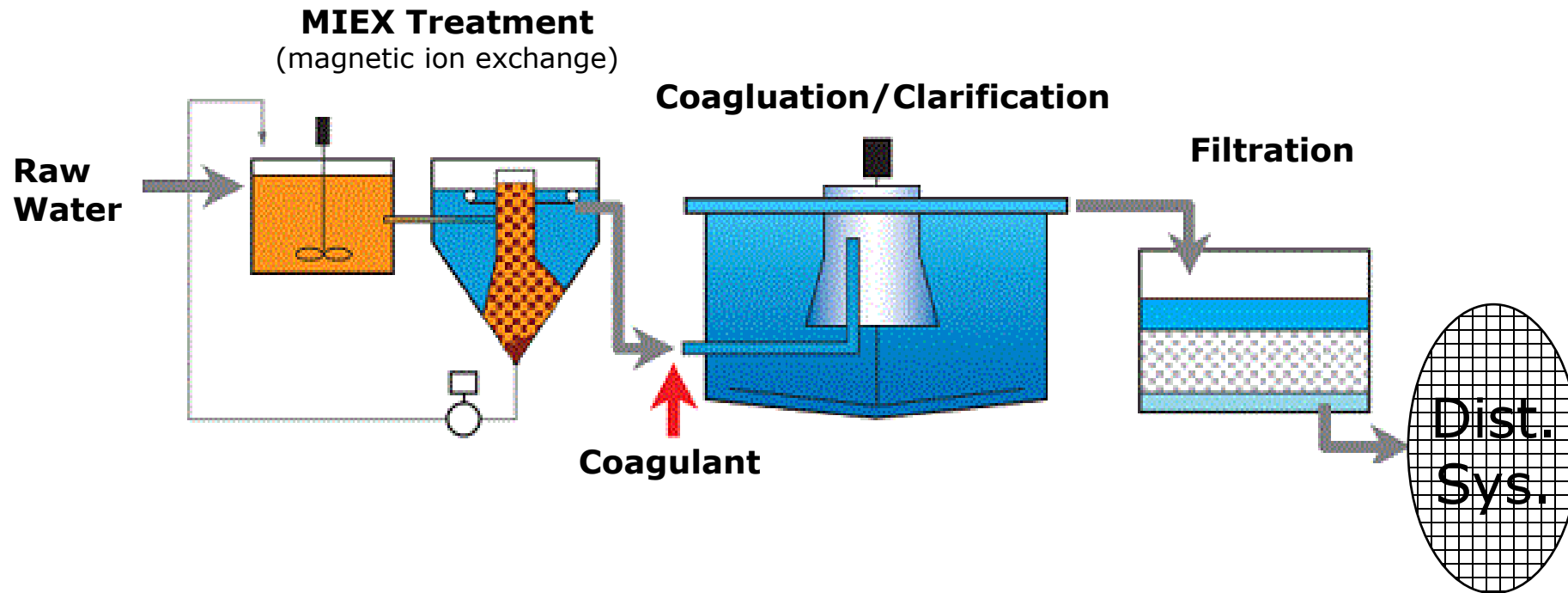
7-Day THMFP Results



# DBP Control Strategies (cont.)

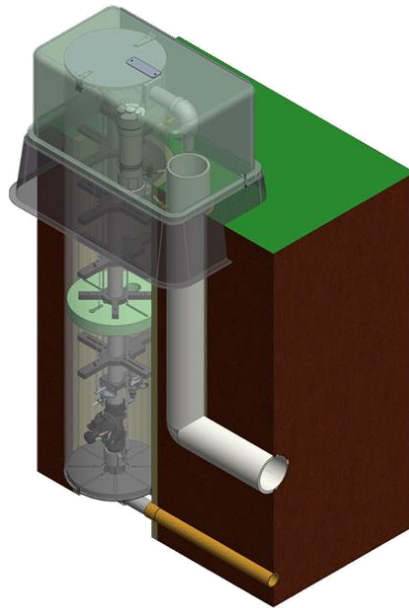
## 2. Remove/Reduce/Modify the level Natural Organic Matter

➤ **MIEX**



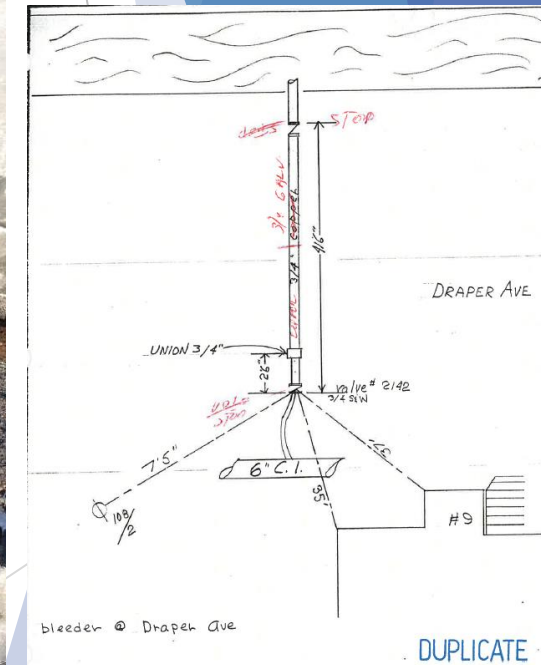
# DBP Control Strategies (cont.)

3. Time - (Water Age) - reduce the reaction time between chlorine and NOM
- **Distribution System Flushing (Manual and Automatic)**
  - *Tank Operations and Mixing - increase cycle time and/or mixing*
  - *Water Main Changes (looping, eliminate parallel mains)*



## Considerations

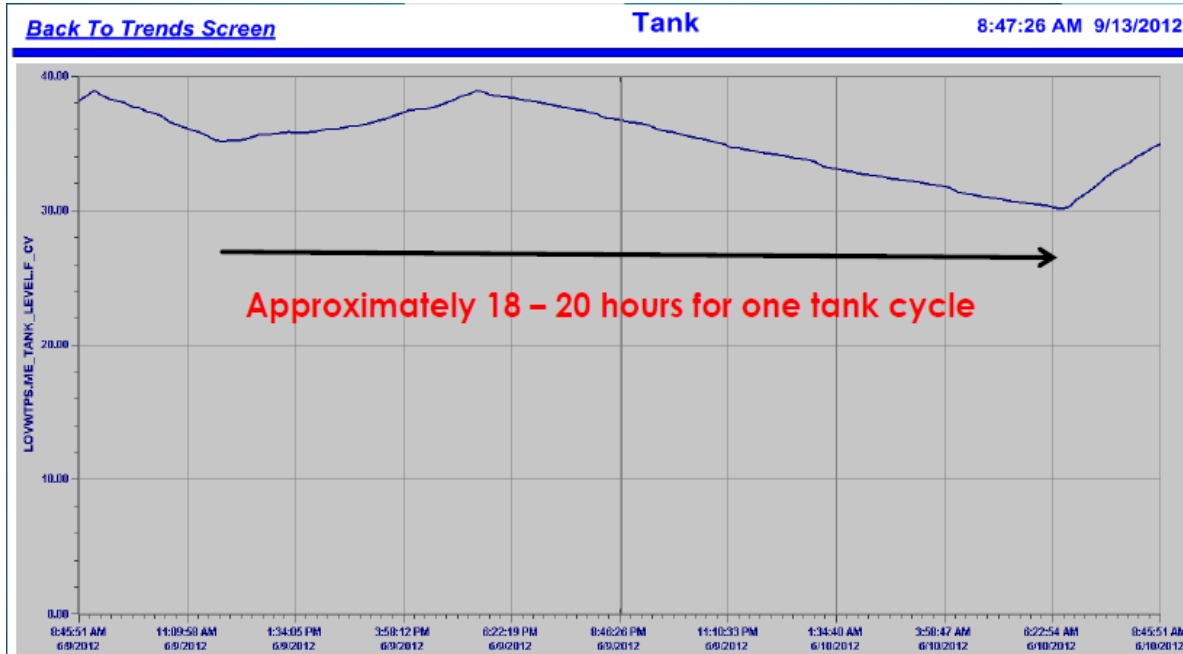
- Frequency
- Season
- Water Use
- Staffing



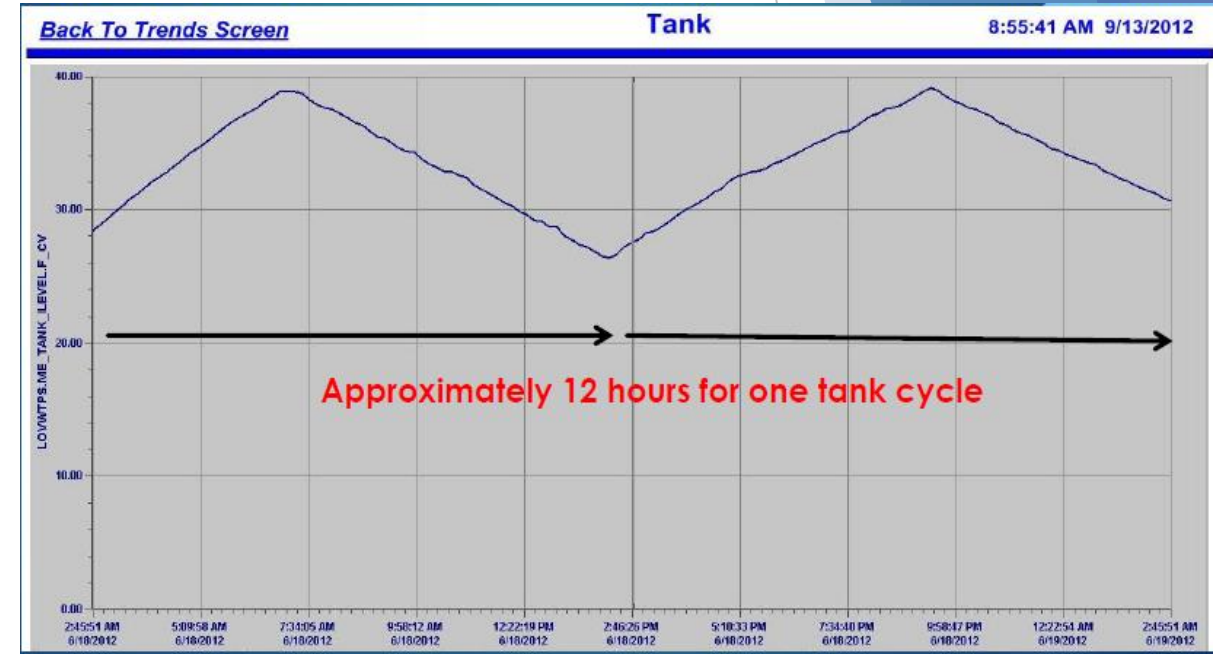
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## 1 Pump Running Continuously



## Pump VFD and SCADA Control P&ID



SCADA Updates to operate finished water pumps based on tank level

# DBP Control Strategies (cont.)

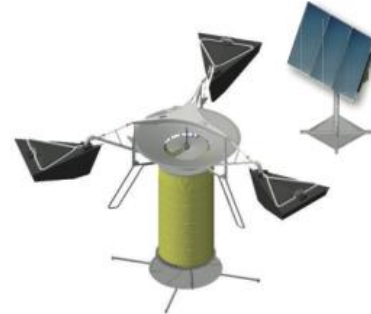
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Passive Mixer



Solar-powered Mixer  
(Small / Medium Tanks)



Solar-powered Mixer (Large Tanks,  
one mixer in 30MG tank)



Elevated  
Impeller Mixer



Elevated  
Nozzle Mixer



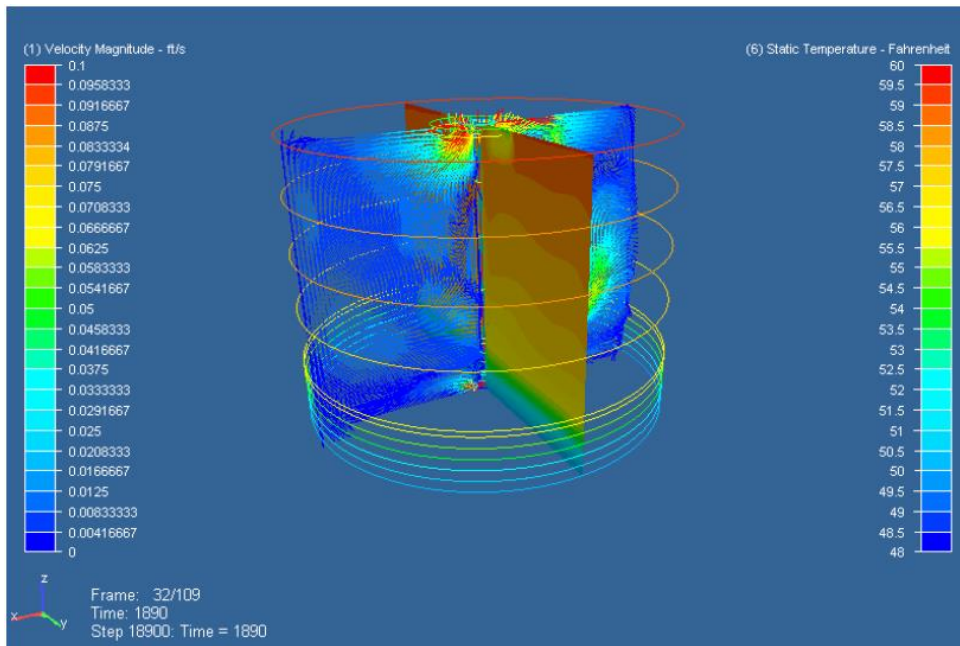
Submersible (floor)  
Sheet-flow Mixer

# DBP Control Strategies (cont.)

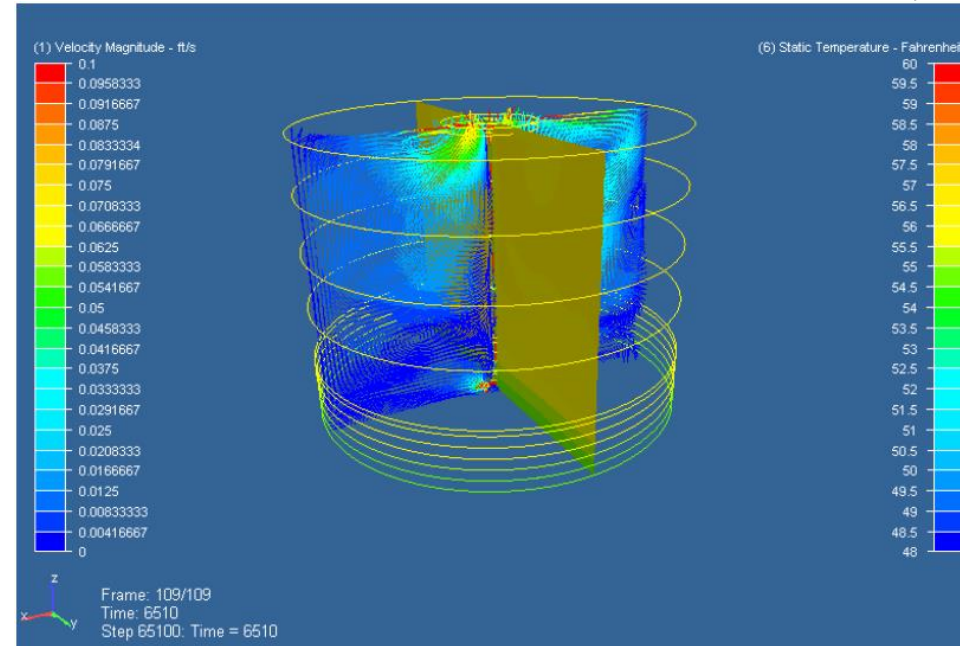
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**Computational Fluid Dynamics (CFD): 5 MG Tank, diameter 170', height 30 ft**

## No Mixing



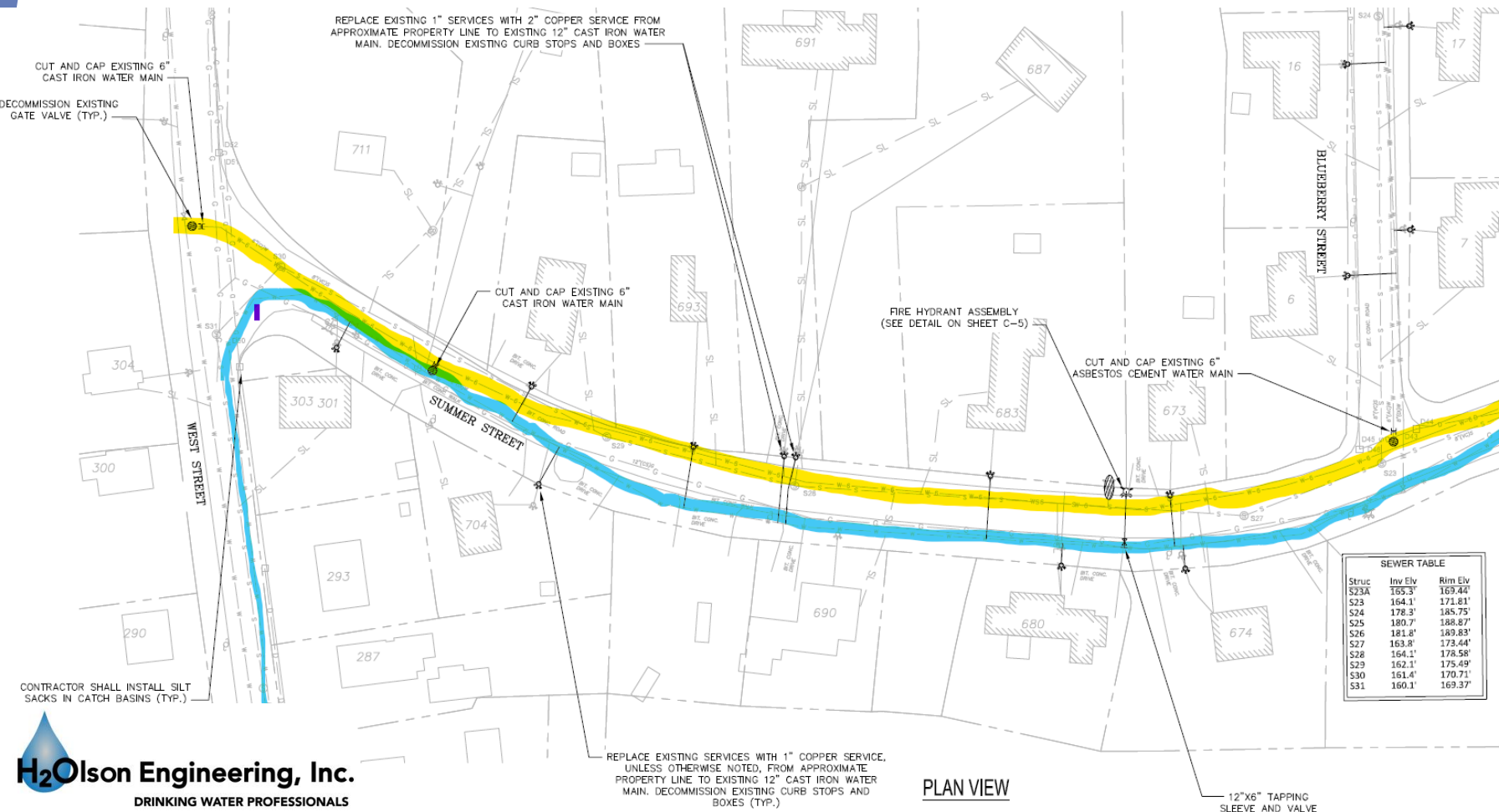
## Mixing



**Mixing reduces temperature stratification and water age**

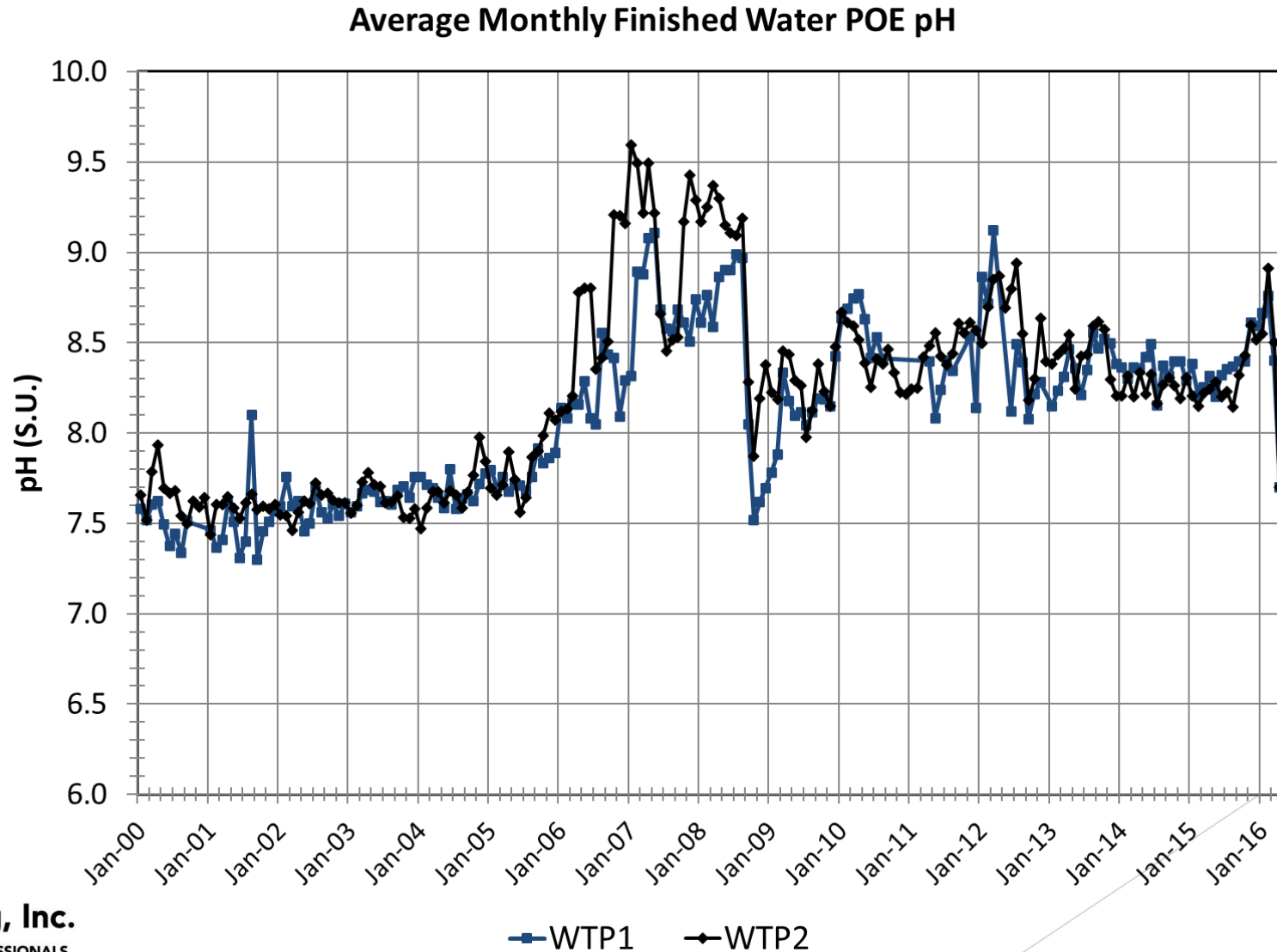
# DBP Control Strategies (cont.)

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# DBP Control Strategies

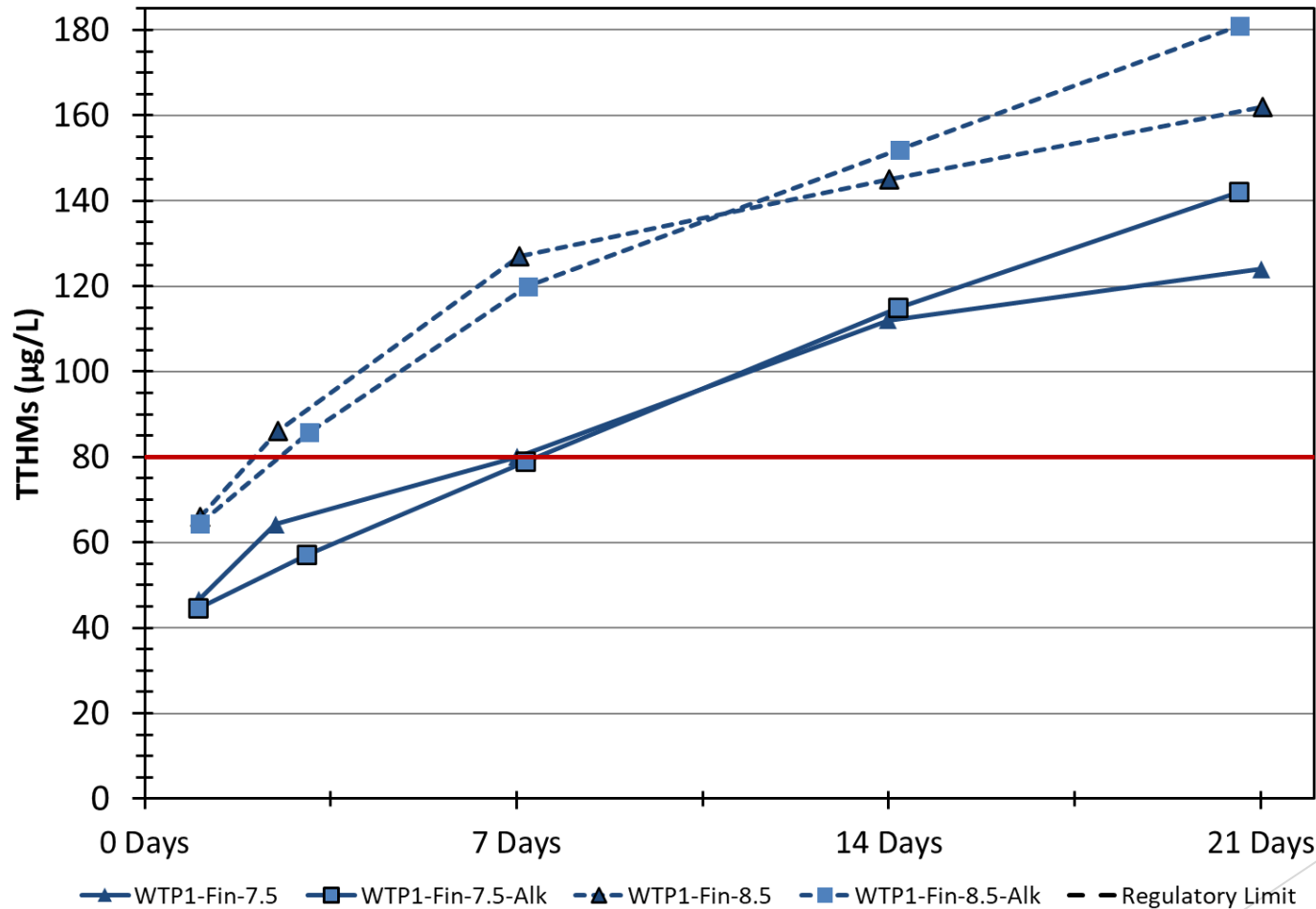
- 4. pH - increasing water pH will result in higher levels of DBPs



# DBP Control Strategies

4. pH - increasing water pH will result in higher levels of DBPs

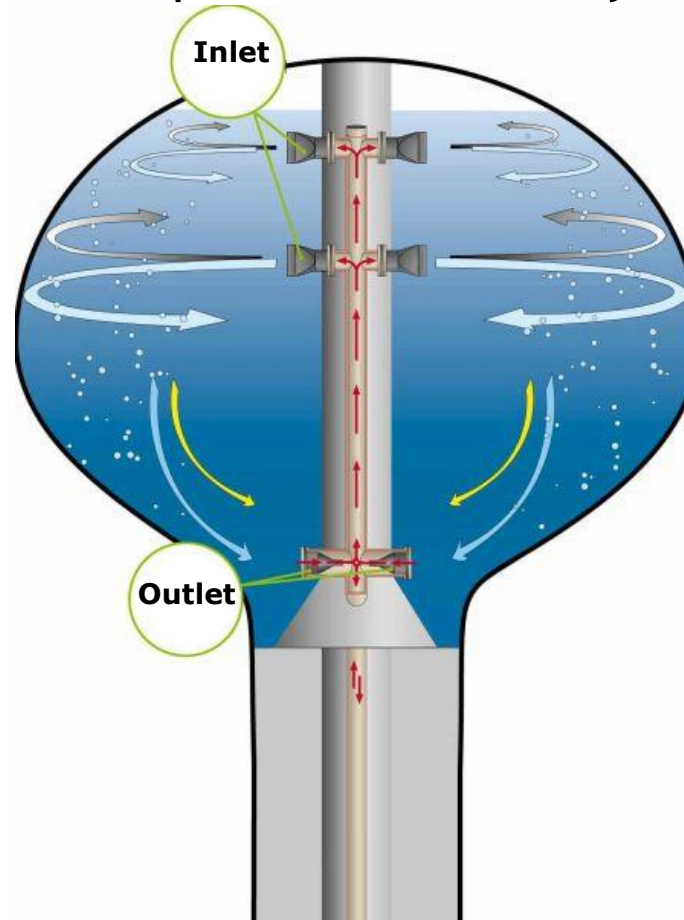
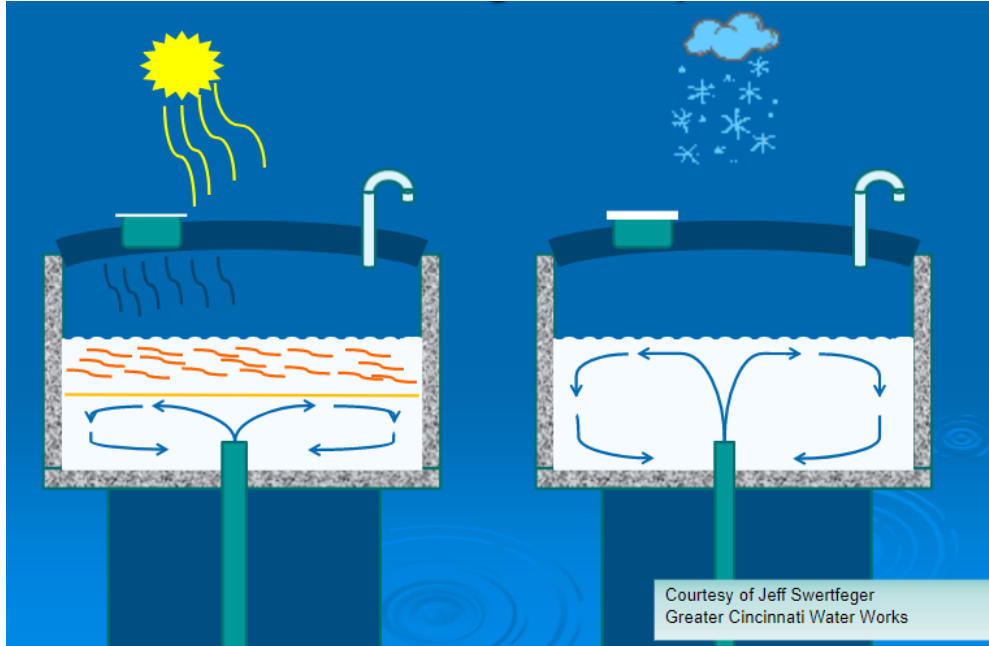
### Simulated THM Results for WTP #1: pH Effects



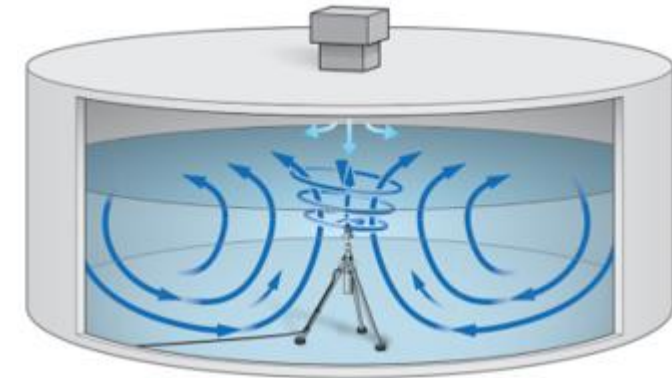
# DBP Control Strategies (cont.)

5. Temperature - there is usually not much you can do about source water temperature, but tank mixing systems can impact distribution system water temperature.

Temperature effects on thermal stratification.



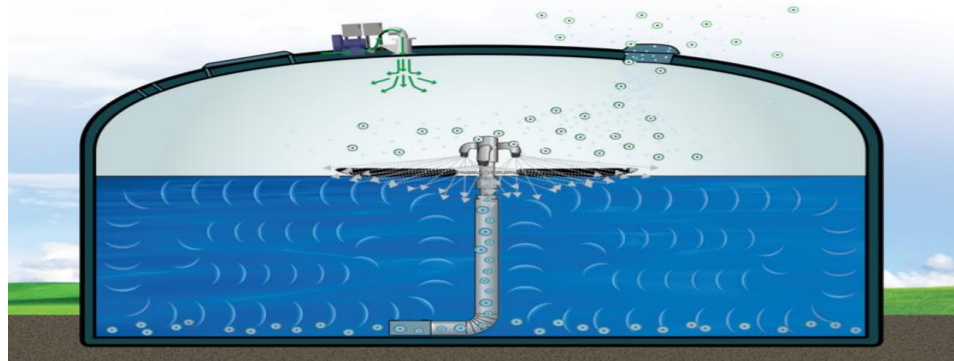
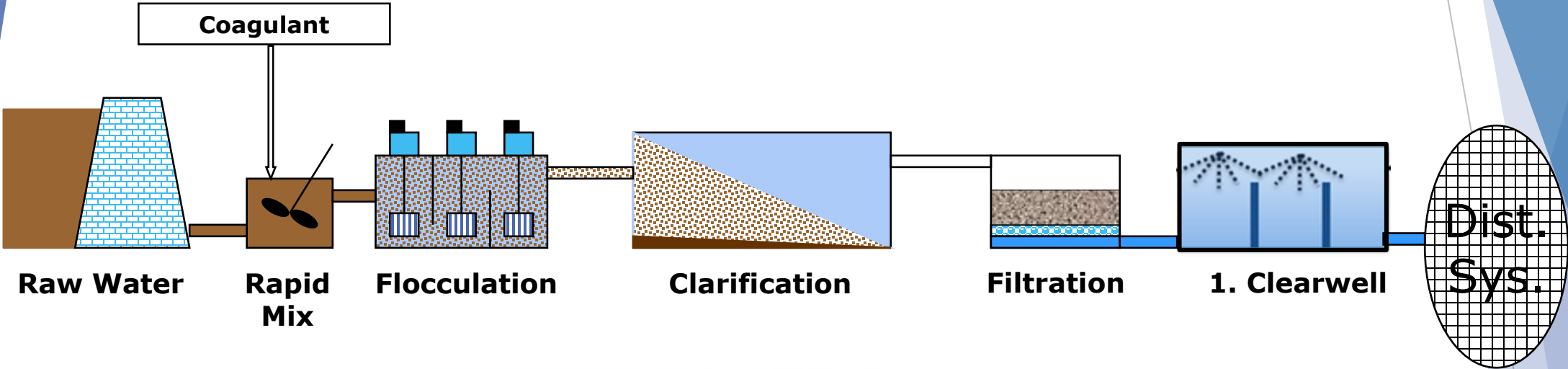
Passive Mixing System



Active Mixing System

# DBP Control Strategies

## 6. Removal after DBP Formation - aeration



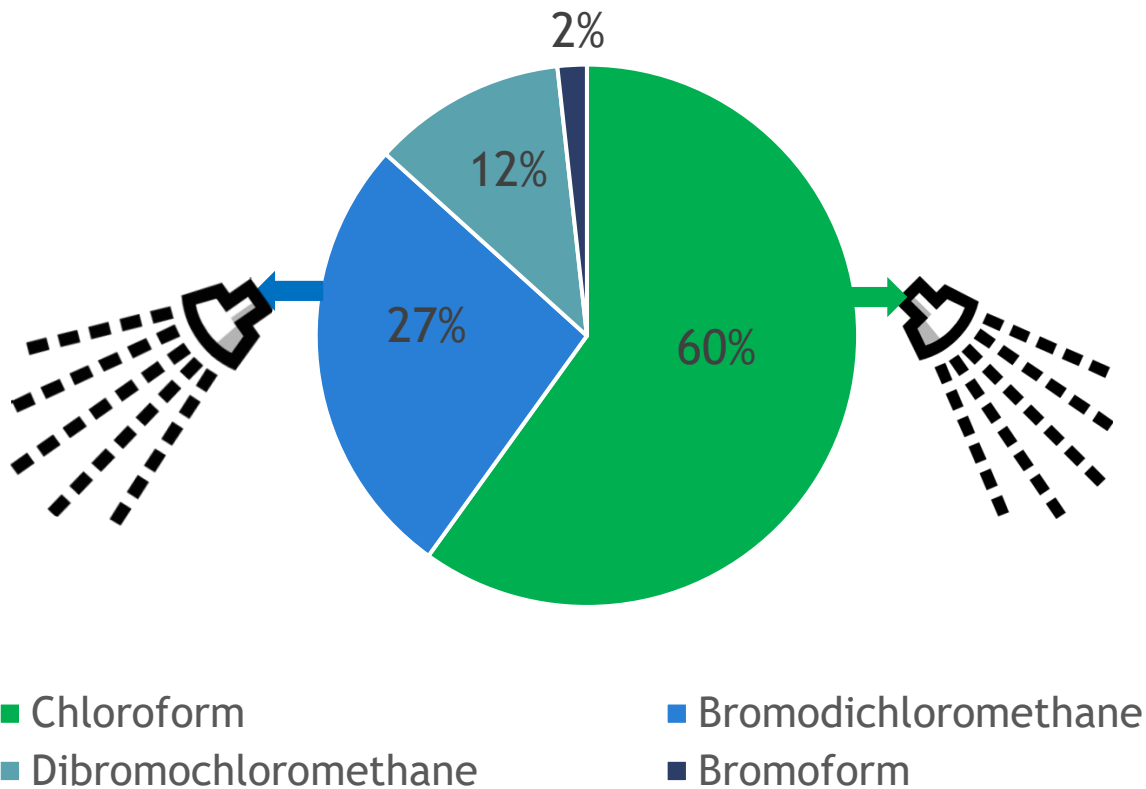
**2. Distribution Storage Tank**

Effectiveness Depends on TTHM Speciation

# DBP Control Strategies

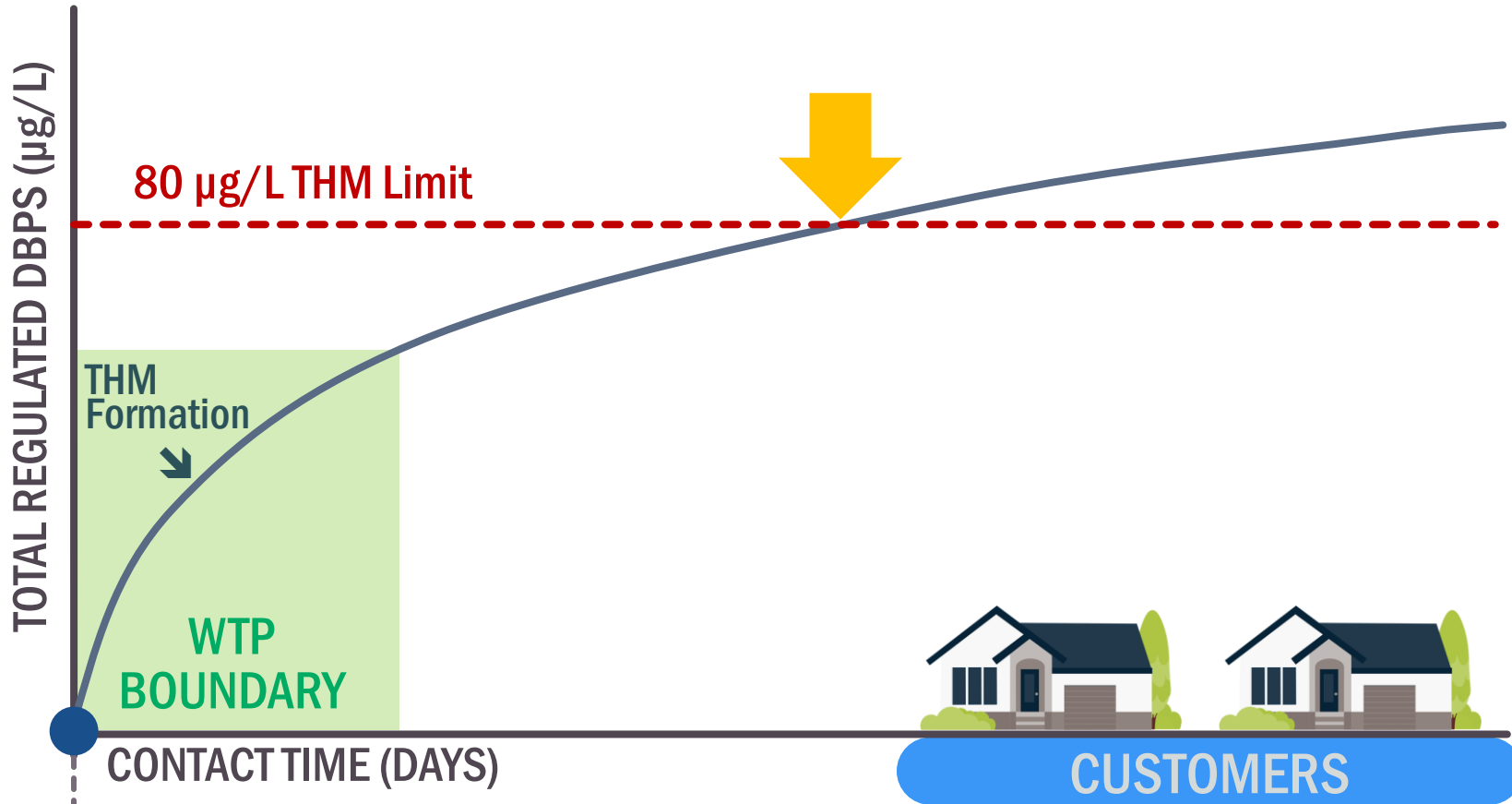
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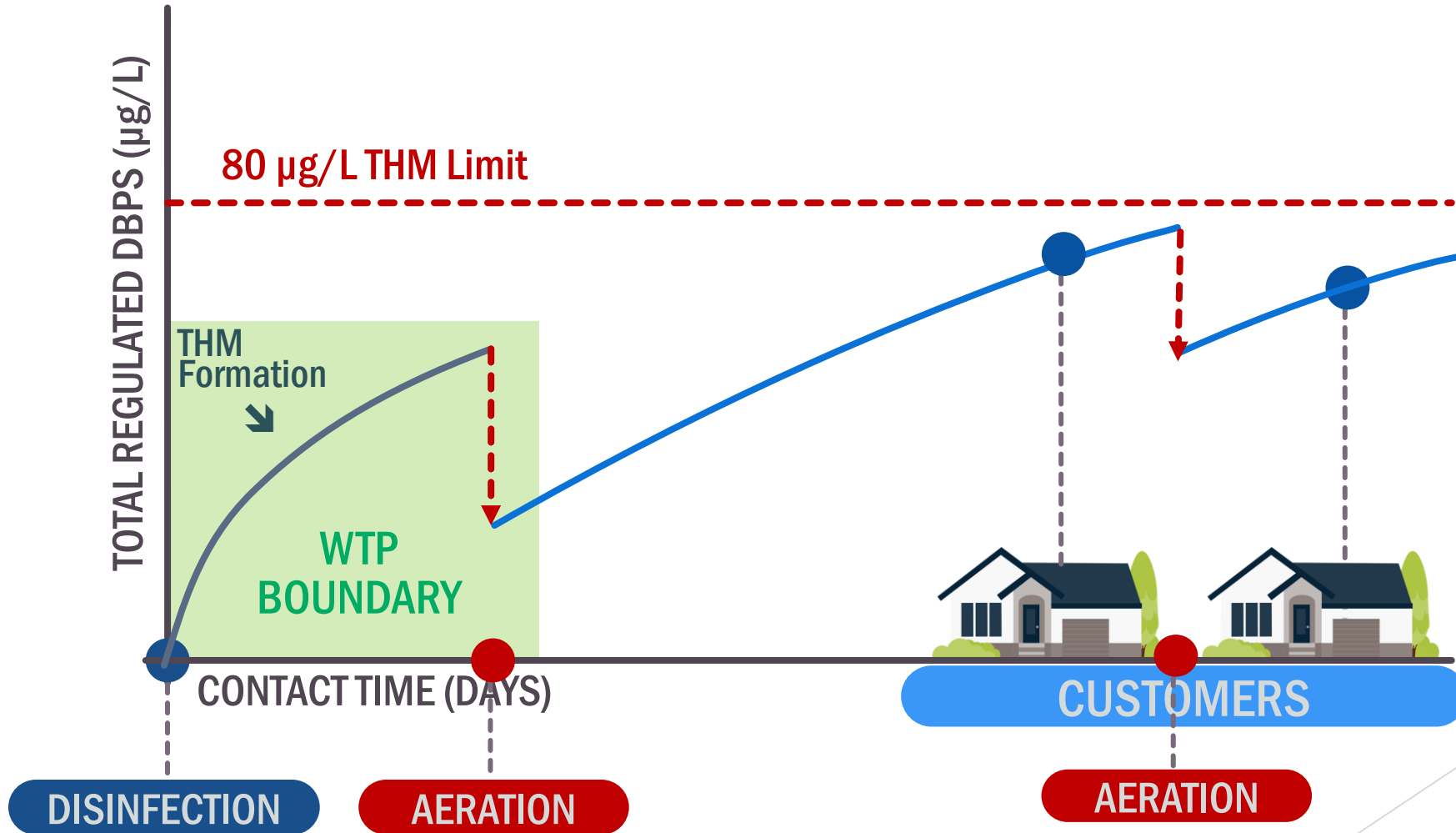
# DBP Control Strategies

## 6. Distribution Storage Spray Aeration - Example

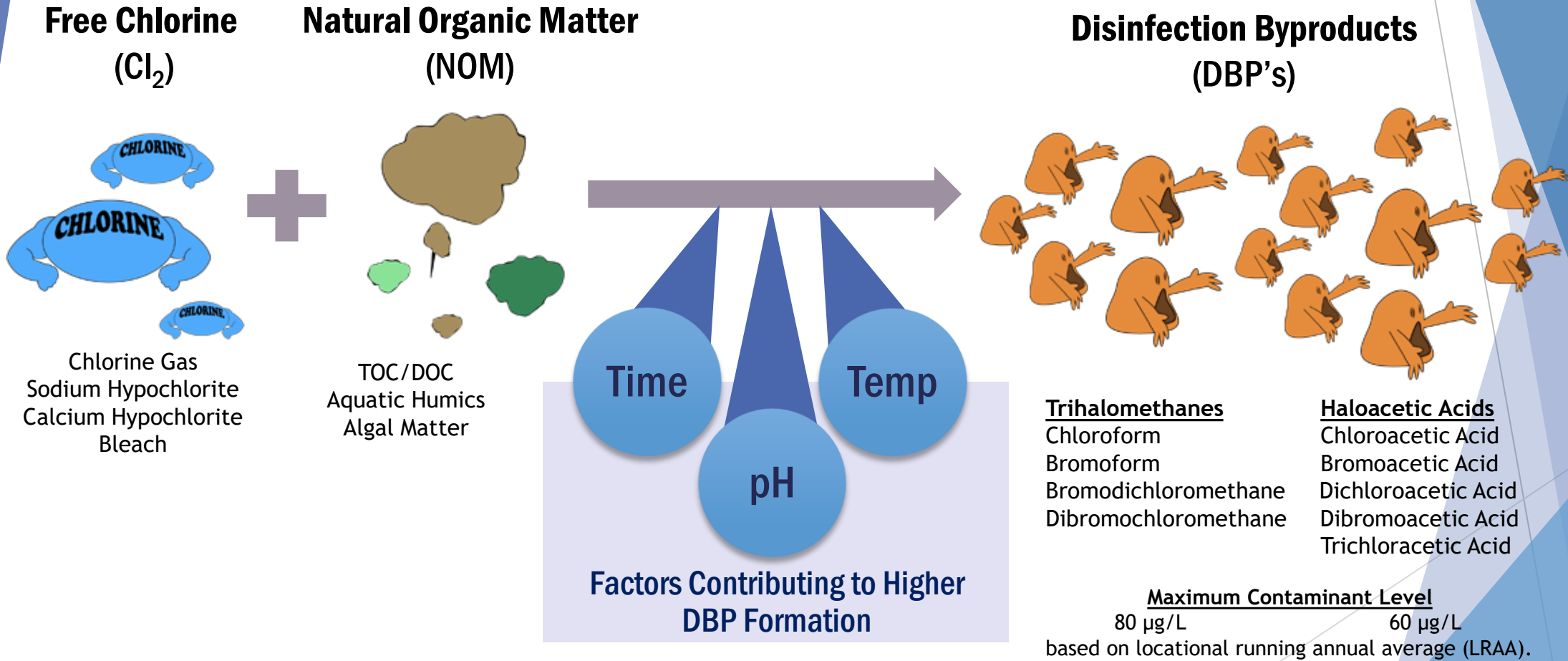


# DBP Control Strategies

## 6. Spray Aeration - Example



# What are DBPs and How are the Formed?



# Questions?

## Contact Information

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