

Chloramination Control

Using the Hach Monochloramine,
Chlorine, and Free Ammonia Tests

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Presentation Outline

Section 1 – Brief Review of Alternative Disinfectants

Section 2 – Discussion of Chloramination

Section 3 – Disinfectant Testing in a Chloramination Plant

Section 4 – Making Sense of the Data

BRIEF REVIEW OF ALTERNATIVE DISINFECTANTS

Alternative Disinfectants - Outline

- Introduction to alternative disinfectants
- Chloramination
 - Chloramination chemistry
 - Chloramination curve
- Testing for disinfectants

Alternative Disinfectants

- What's the problem with chlorine?
 - Chlorine is very reactive with organic matter to form halogenated DBPs.
 - For some systems, this poses no problems.
 - For some systems, chlorine is a major contributor to a DBP problem.

Alternative Disinfectants

- Alternative to chlorine which:
 - Adequately disinfects
 - Maintains residual
 - Removes taste and odor compounds
 - Practical
 - Minimizes reactions with natural organic matter that form DBPs

Alternative Disinfectants

- The main alternative disinfectants that drinking water plants use are chloramines and chlorine dioxide.

Alternative Disinfectants

- Newer plants are also switching to:
 - Ozone
 - No residual, bromate by-product
 - UV Disinfection
 - No residual, destroys organic material

Chloramines

- Chloramines are formed when free chlorine reacts with free ammonia present in the water
 - Monochloramine (NH_2Cl)
 - Dichloramine (NHCl_2)
 - Trichloramine (NCl_3)

Chloramination Benefits

- Reduces formation of halogenated DBPs
- Maintains residual
- More economical than alternatives

Chloramination Drawbacks

- Weaker disinfectant requires higher dose or longer contact time
- Nitrification problems if excess ammonia
 - Biological growth in the distribution system
 - Microbial conversion of ammonia to nitrite and nitrate

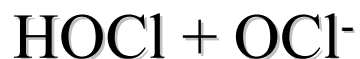
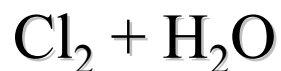
DISCUSSION OF CHLORAMINATION

Chloramines

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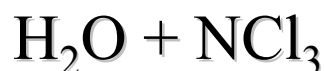
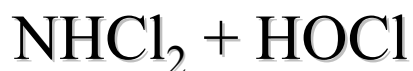
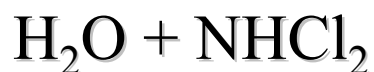
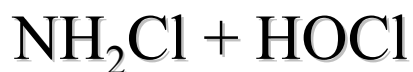
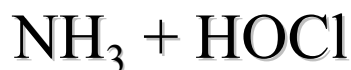
Chloramination Chemistry

Free Chlorination:



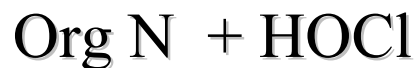
(strong disinfectant)

Chloramination:



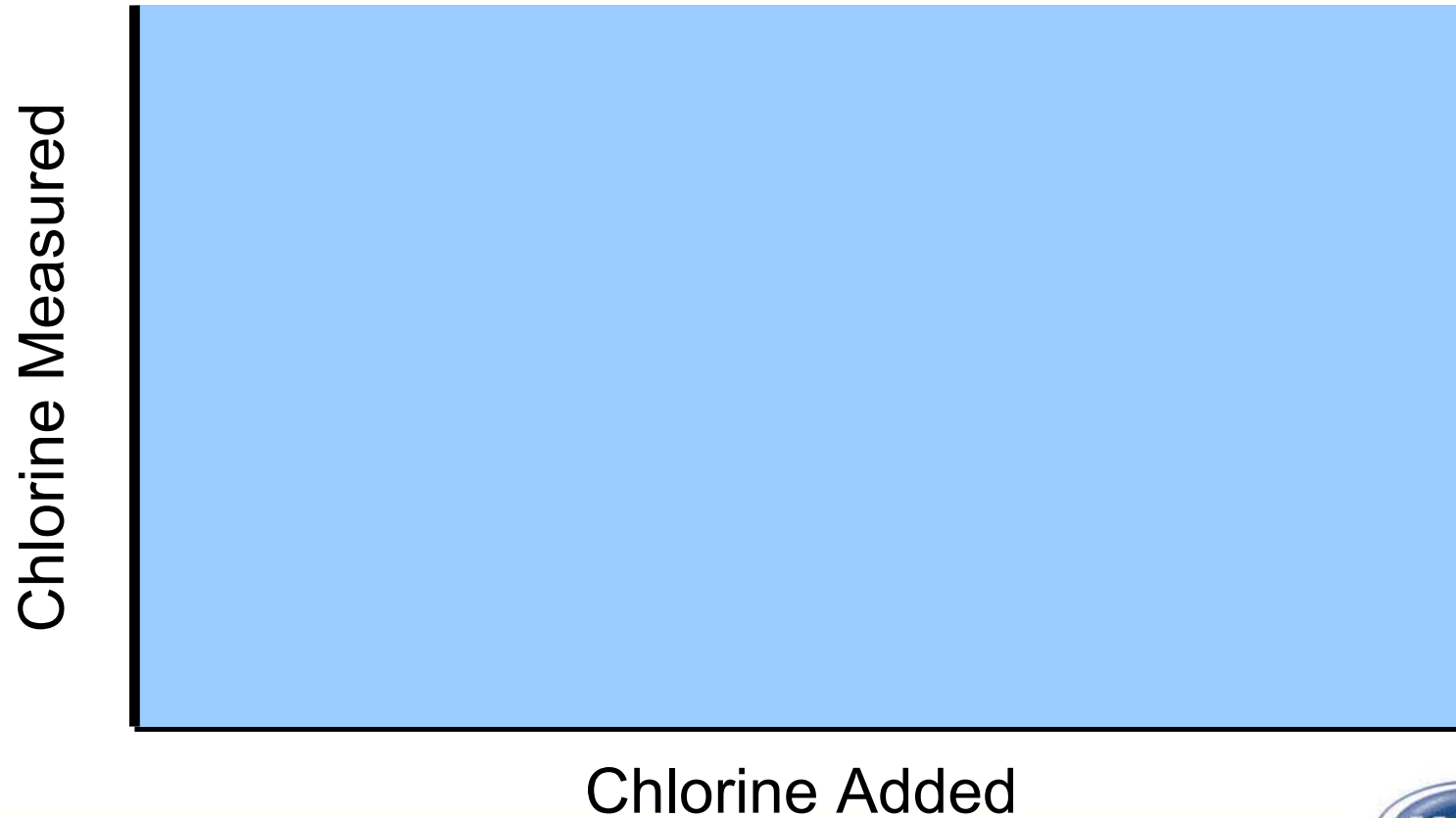
Increasing
disinfection
efficiency
↓

Organic Amines:



(unknown disinfecting)

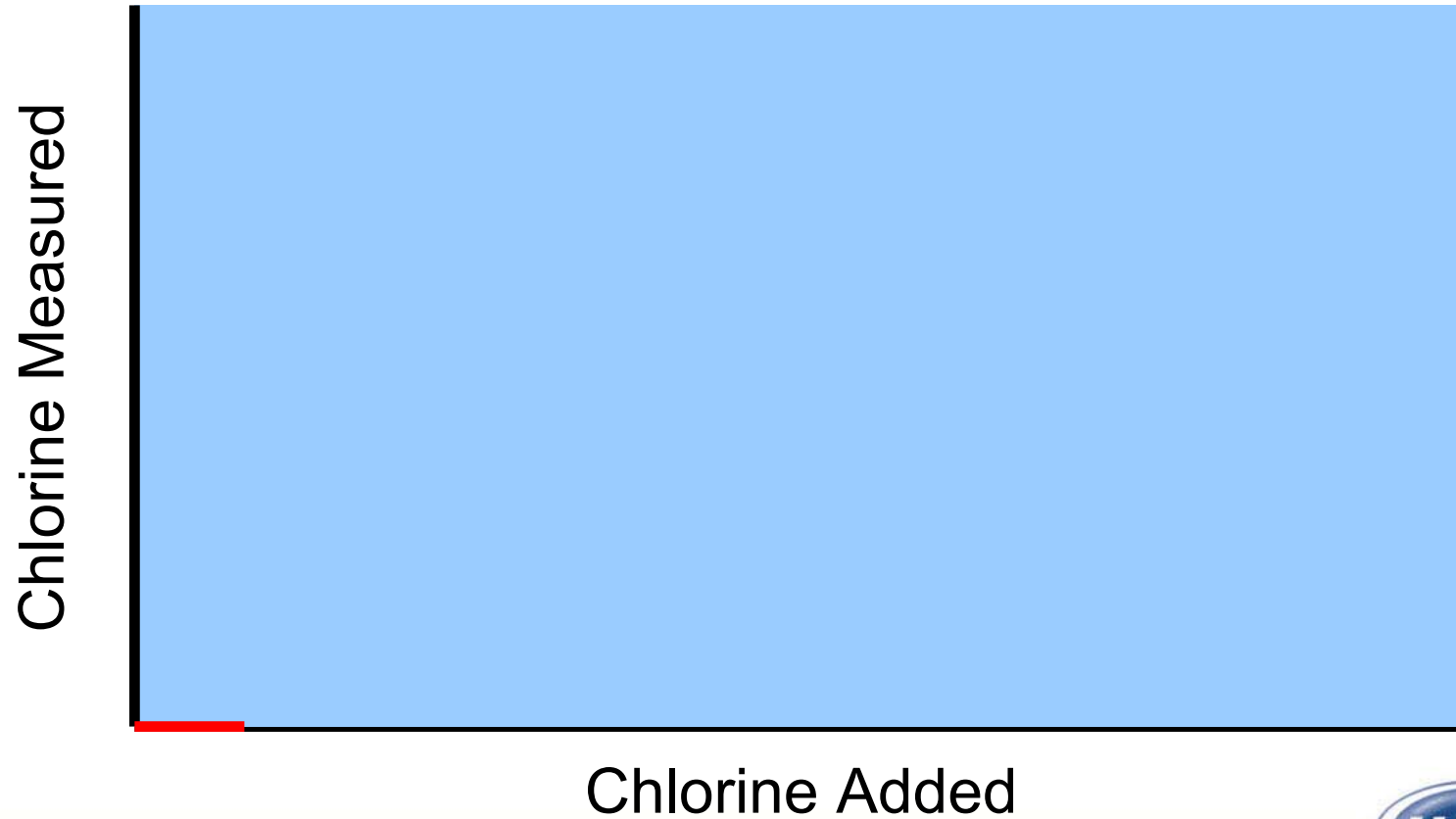
Chloramination Curve



Chloramination Curve

- Begin adding chlorine to a water containing ammonia
 - Initial addition of chlorine reacts to exhaust any chlorine demand present in the water

Chlorination Curve

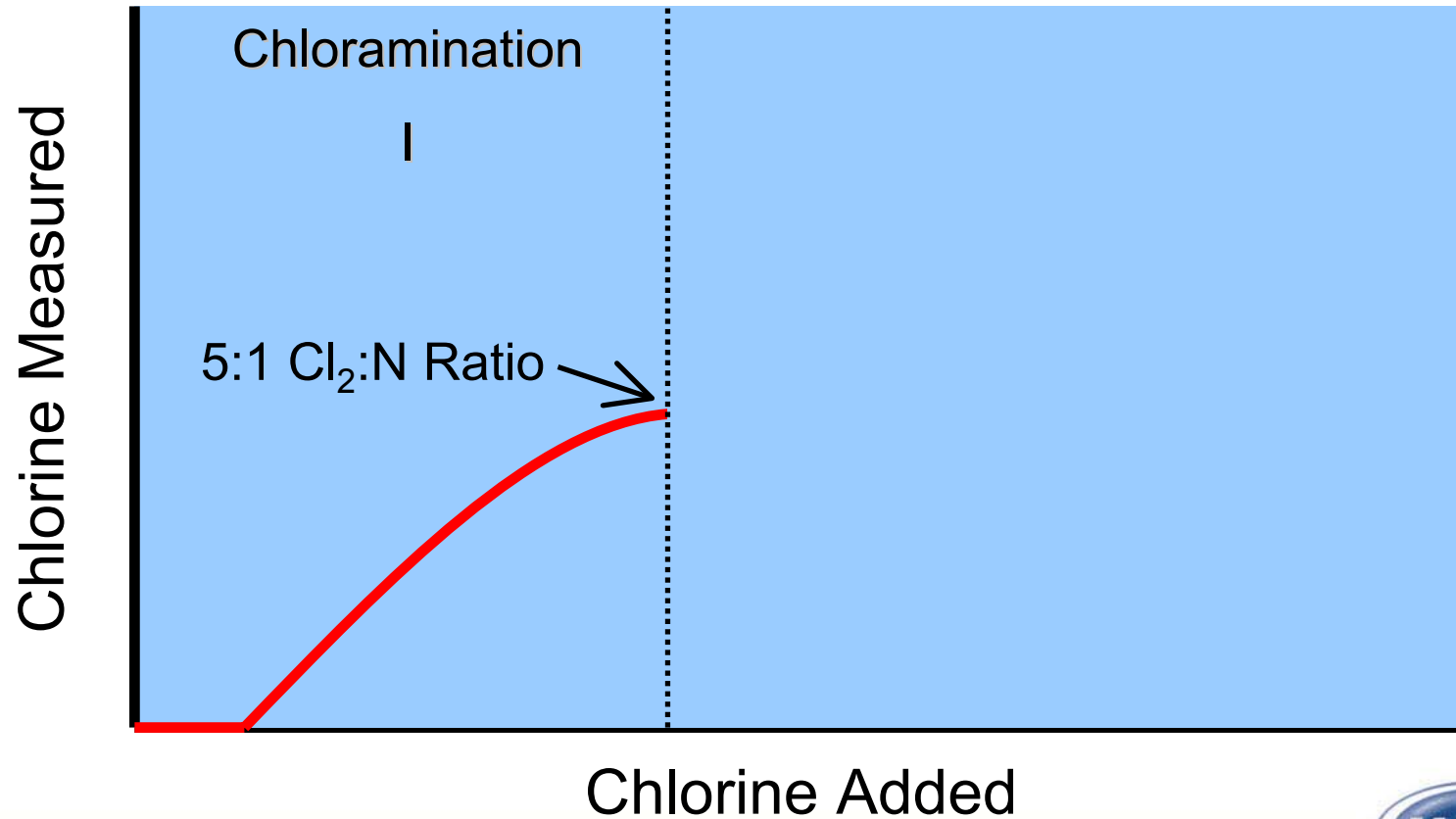


Chloramination Curve

- Continue to add chlorine to the water
 - After chlorine demand is exhausted, chlorine reacts with ammonia to form monochloramine



Chlorination Curve



Chloramination Curve

- Continue to add chlorine to the water
 - After complete formation of monochloramine, monochloramine reacts with additional chlorine to form dichloramine and nitrogen trichloride.



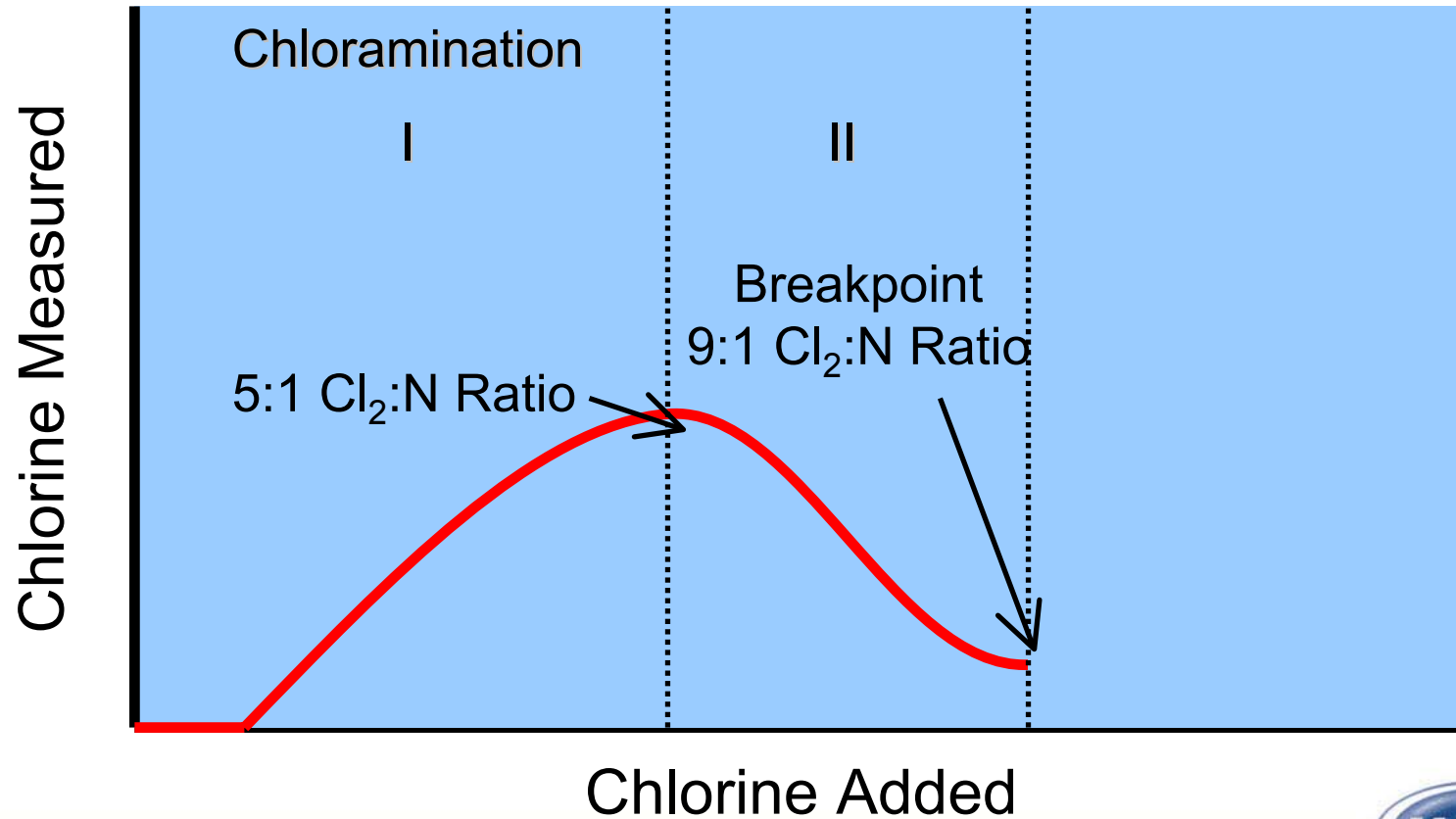
Chloramination Curve

- Continue to add chlorine to the water
 - As dichloramine and nitrogen trichloride form, the addition of chlorine continues to oxidize these compounds to nitrogen gases

Chloramination Curve

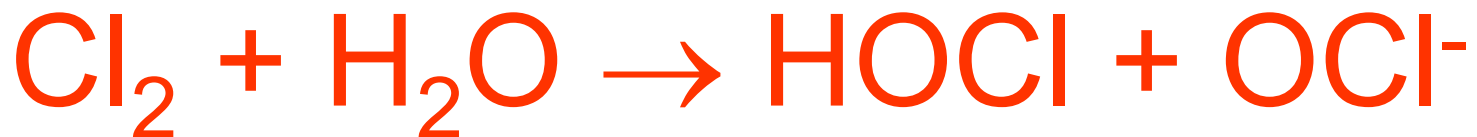
- Continue to add chlorine to the water
 - The point at which all dichloramine is converted to nitrogen gas is the *breakpoint*.

Chlorination Curve

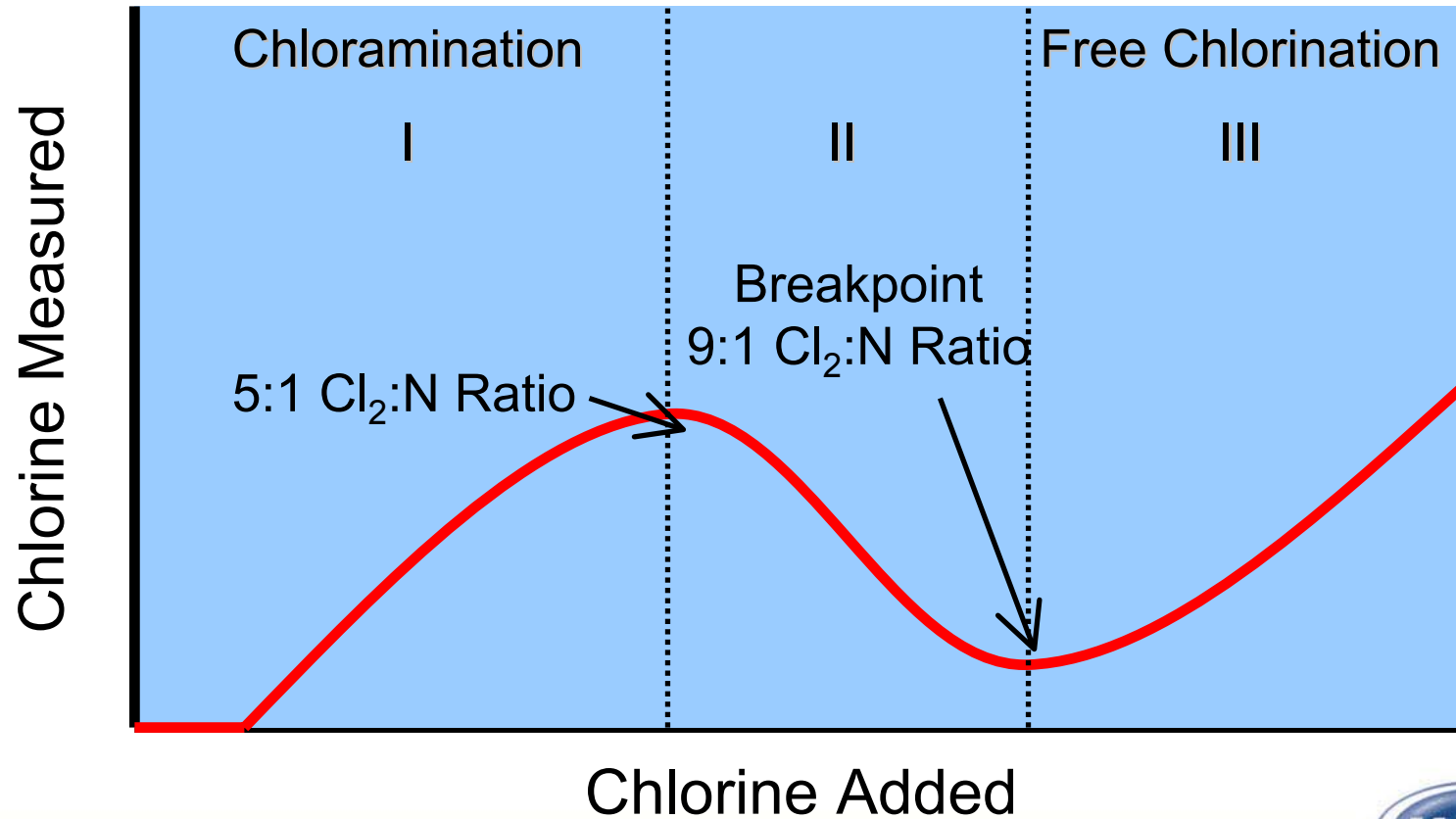


Chloramination Curve

- Continue to add chlorine to the water
 - After the breakpoint, all chlorine added to the water remains as free chlorine
 - Breakpoint chlorination



Chlorination Curve



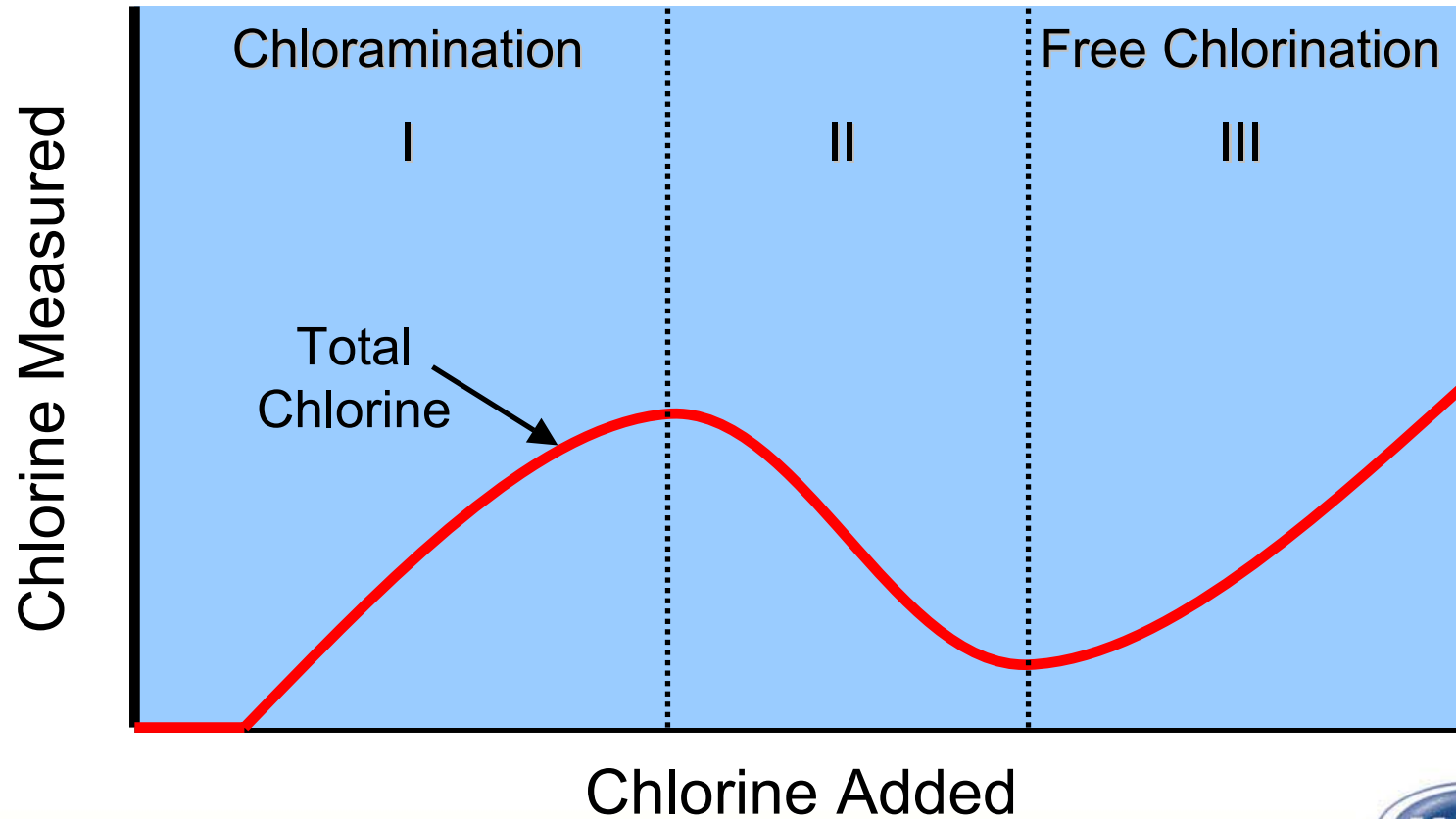
Chloramination Goals

- Complete formation of monochloramine (stay in section I)
 - 3-5:1 Cl_2 :N optimal feed ratio
- Avoid dichloramine formation
 - Avoid taste and odor problems
- Minimize un-reacted ammonia
 - Control biofilm and nitrification

Chloramination Species

- Curve we have been looking at is total chlorine
- What other species are involved in chloramination and what happens to their concentrations?

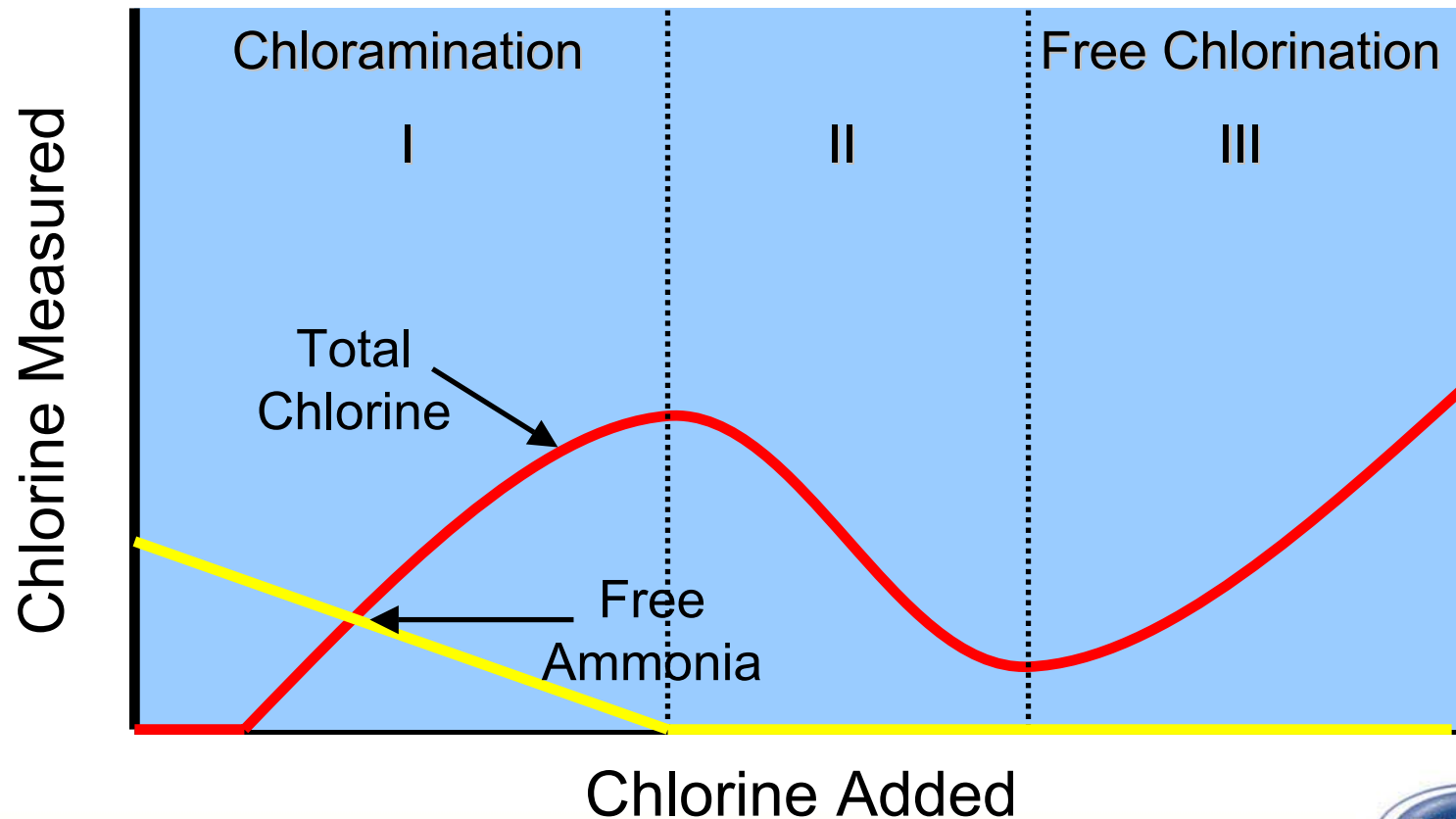
Chloramination Species



Free Ammonia

- Free ammonia reacts with chlorine to form monochloramine until ammonia has been consumed

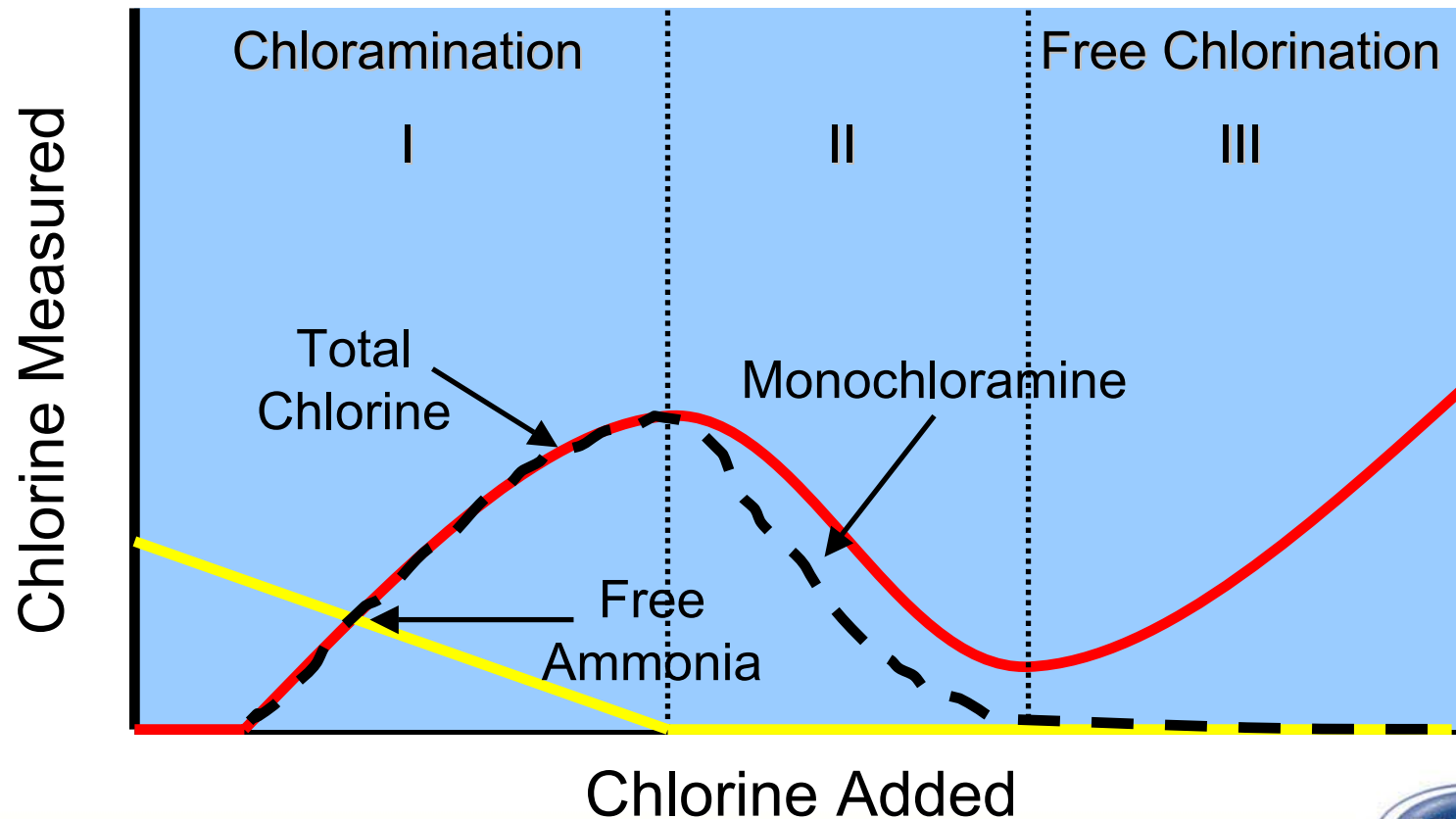
Chloramination Species



Monochloramine

- Monochloramine is equivalent to total chlorine until Section II where it reacts with chlorine to form new compounds.
- No monochloramine remains at the breakpoint.

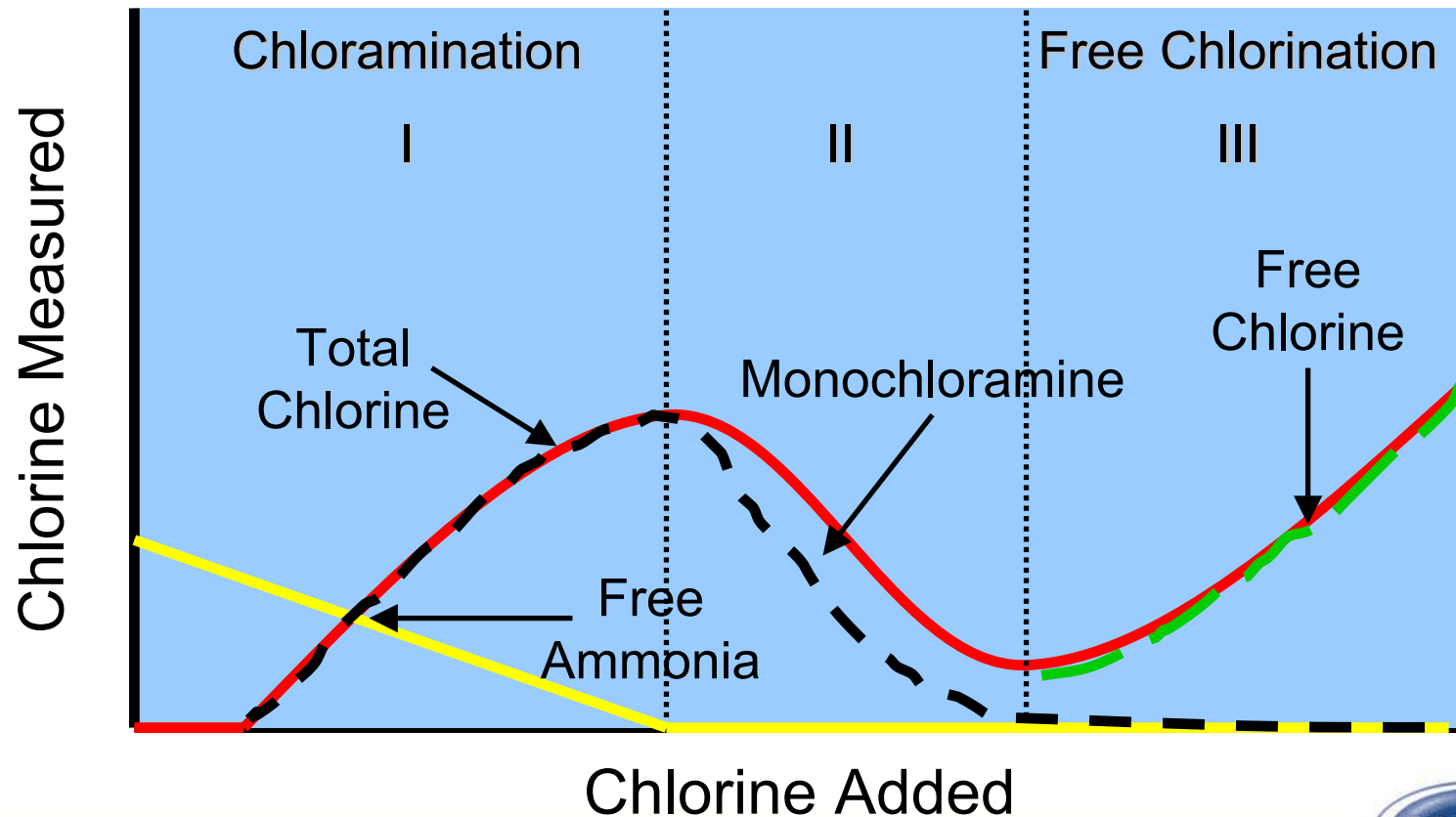
Chloramination Species



Free Chlorine

- Free chlorine does not exist until after the breakpoint.
- After the breakpoint, all chlorine added to the system exists as free chlorine.

Chloramination Species



DISINFECTANT TESTING IN A CHLORAMINATION PLANT

Chloramination Species

- There's a lot going on in chloramination - how can a plant keep this process in control?
- Hach has tests that can help!

Chloramination Monitoring

- Monitor chloramines using:
 - Monochlor-F method
 - New chemical method specific for monochloramine
 - Few interferences
 - Optimized for chloramination monitoring

Chloramination Monitoring

- Monitor ammonia using:
 - The New Indophenol method
 - Two Tests in One (Monochlor-F and Free Ammonia)
 - Optimized performance
 - Optimized for ppb levels of Free Ammonia

Chloramination Monitoring

- Monitor chloramination process using:
 - Total chlorine
 - Free chlorine
 - Be aware of where free chlorine exists in chloramination

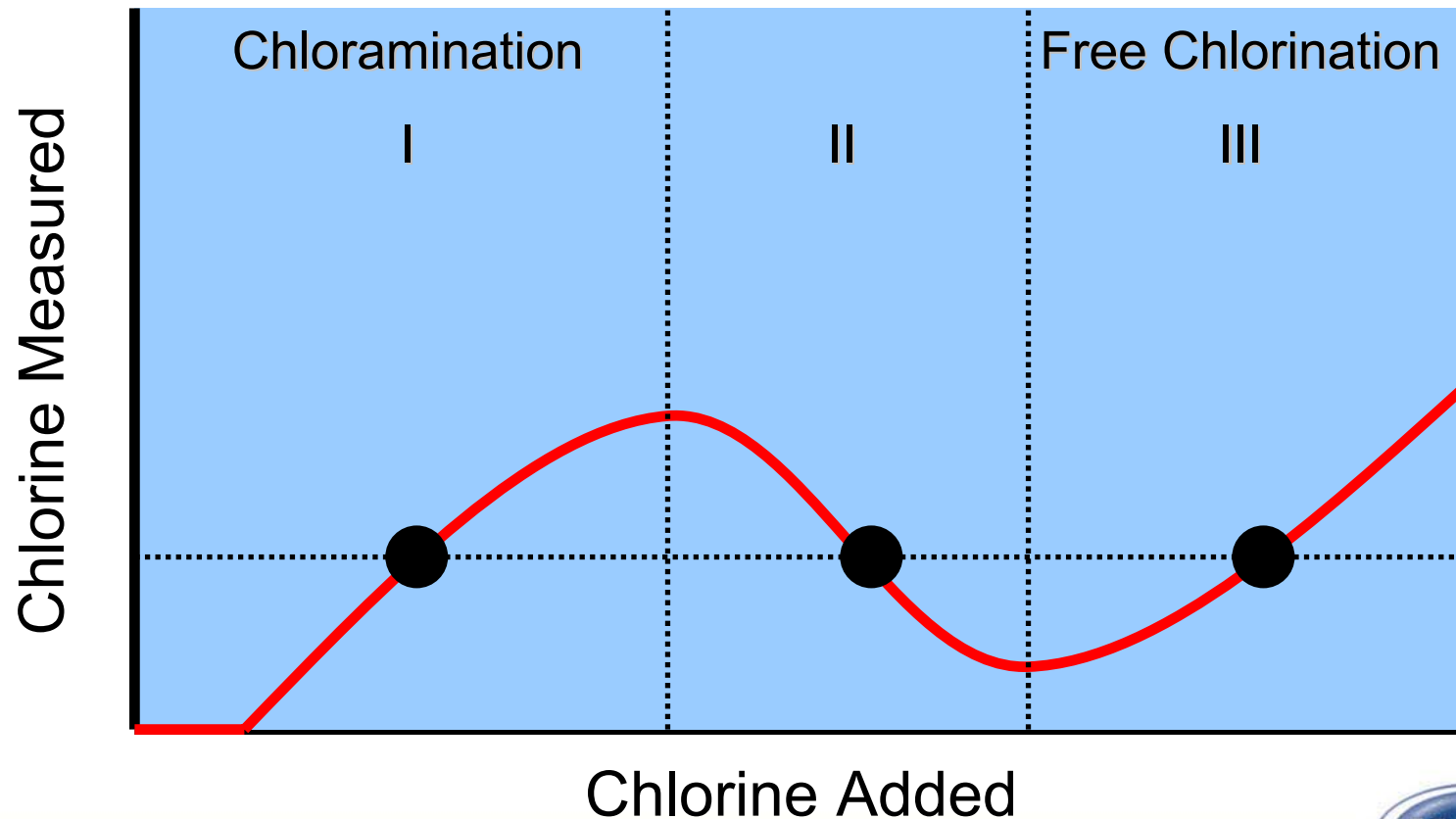
MAKING SENSE OF THE DATA

Making Sense

- Chloramination - Why so many tests?
 - Combination of ammonia and monochloramine (and maybe total chlorine) lets you know exactly where your process is on the breakpoint curve
 - Keeping process under control saves time and money

Where Am I When...

Total Chlorine = 3mg/L?



I Am Here! Makes sense!

