Nitrification Action Plans

Texas Section
American Water Works Association
In conjunction with TCEQ

November 17, 2016

Speakers

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Nitrification:
Overall take-home message

• Nitrification is a risk in chloraminated distribution systems. It can cause low total chlorine residuals and coliform positives.
• A Nitrification Action Plan (NAP) is a tool to prevent and respond to nitrification.
  • Monitoring and trend analysis will tell you what’s happening. • Looking at data trends can help you catch nitrification before it ‘blooms.’ • And, if it does happen, the NAP describes how to respond.

Outline of Webinar

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans
5. Assistance Opportunities
Detailed outline of webinar

1. History and overview of nitrification in Texas
   (3 intro+15 slides, 5 min.)
2. Chloramine chemistry review
   The breakpoint curve (9 slides, 10 min.)
3. Nitrification—detailed discussion from 3 views:
   Macro, Micro, and PWS Data (24 slides, 25 min.)
4. Nitrification Action Plans
   4a. NAP map, sites, and schedules (21 slides, 20 min.)
   4b. Analytical methods (15 slides, 13 min.)
   4c. Goals/baselines (16 slides, 12 min.)
   4d. Triggers (13 slides, 10 min.)
   4e. Corrective actions (9 slides, 10 min.)
   4f. Communication (8 slides, 5 min.)
5. Assistance Opportunities (10 slides, 5 min.)

Outline of Webinar

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans
5. Assistance Opportunities
Nitrification has caused residual loss in Texas public water systems that disinfect their distribution system with chloramines.

- As more systems used chloramines to control disinfection byproducts (DBPs), nitrification was found more frequently.
- After about 15 years of experience with nitrification, the drinking water industry and TCEQ have developed procedures to deal with it.

What is nitrification?

- **Short answer:**
  - Nitrification is a biological process that can happen in chloraminated distribution systems.
  - Systems with chloramines have ammonia present.
  - Nitrifying bacteria ‘eat’ ammonia.
  - When the nitrifying bacteria eat the ammonia, it can cause **loss of total chlorine residual**.
    - Allowing bacterial regrowth and potential persistence of pathogens.

- **Long answer:**
  - A lot more slides, later.
How did we get here? Why are we even talking about NAPs?

- Around 2000, more public water systems (PWSs) started using chloramines in response to (or to prepare for) the Stage 1 DBP Rule.
  - Free chlorine forms more DBPs than chloramines.
  - Some PWSs that used chloramines had problems holding their total chlorine residual, to the point where they had Total Coliform Rule (TCR) violations.
- In many cases, this was caused by... Nitrification!

How did we get here? Why are we even talking about NAPs?

- Chloramines naturally release ammonia as they degrade.
  - That would not be a problem—ammonia is not toxic at those low levels—except that having ammonia present provides food for the nitrifying bacteria.
What is nitrification?

Ammonia-oxidizing bacteria (AOB) 'eat' ammonia, and produce nitrite ($\text{NO}_2^-$).

In the process, total chlorine residual is destroyed.

Nitrite-oxidizing bacteria (NOB) 'eat' nitrite, and make nitrate ($\text{NO}_3^-$).

Lessons learned:

2003—Central Texas

- City with SWTP
  - Fish kill complaint
- Water quality data:
  - Monochloramine 1.5 mg/L
    - (Other sites: 2.5 mg/L)
  - Ammonia 0.5 mg/L
    - (Other sites: 1.75 mg/L)
  - Nitrite in distribution: 1.56 mg/L
    - (At entry point: ~0.4 mg/L)
- Residual loss was due to nitrification:
  - Nitrification can occur WITH good residual
  - Don’t ignore complaints about dead fish
11/17/2016

How did we get here?

**Question: How much does this happen?**

**2005 Summer—Special Study**

- Sampled in distribution—at DBP sites:
  - Nitrate, nitrite, and ammonia.
- Data was evaluated for trends:
  - Higher nitrite or nitrate than at entry point.
    - Potential production of nitrite and/or nitrate by nitrifying bacteria.
  - High ammonia:
    - Potential for presence of ‘food’ for nitrifying bacteria.

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**Question: How much does this happen?**

**Answer: Enough to be an issue.**

- In the 2005 special study, we learned:
  - Approximately **10%** of systems may be experiencing nitrification, but in this study only **1%** had extreme problems.
  - Nitrification happened under a range of conditions, **all over Texas**.
    - Surface water, ground water.
    - Large and small systems.
Since 2005...

Numerous challenges continued

• Over time, drinking-water industry best practices were developed to avoid and respond to nitrification.
  • These best practices were combined in the Nitrification Action Plan (NAP).
• Until July 30, 2015, NAPs were required on a case-by-case ‘TCEQ Exception’ basis.
  ▫ Since then, NAPs and the associated monitoring are required for all Texas PWSs with chloramines
    • Including purchased-water systems and transient non-community (TNC) PWSs.
    • ‘Blending’ systems still need a ‘TCEQ Exception’.

History of Nitrification in Texas:
Take-home message

Nitrification can be a problem in public water systems that disinfect their distribution system with chloramines.

As more systems started using chloramines to control disinfection byproducts, nitrification was found more frequently.

Nitrification can be controlled using a Nitrification Action Plan.
Outline of webinar

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans
5. Assistance Opportunities

Maintaining a stable chloramine residual helps prevent nitrification.

Total chlorine, monochloramine, and free available ammonia must be measured to evaluate and control chloramine stability using the breakpoint curve.
Chloramine review

• It is good to have a working knowledge of chloramine chemistry to understand nitrification.
  ▫ This topic is covered more completely elsewhere.

• The following is a brief overview.

Breakpoint curve discovery

• Adding chlorine to water with ammonia in it does not act like you think it should.

![Breakpoint Curve Diagram]

Total Chlorine (mg/L) = Sum of all active chlorine species

Chlorine added to water (~Cl₂: NH₃-N Ratio)
Breakpoint curve

Total Chlorine = The sum of all active chlorine species

- Mono-chloramine
- Dichloramine
- Free Chlorine
- Trichloramine

Total Cl, Free Ammonia Residual

Breakpoint curve

Dichloramine (and others) form and decay, free ammonia is not present. Disinfection is inadequate.

- Monochloramine dominates, free ammonia is present & decreasing (Cl₂:NH₄-N mass ratio 0:1 to 5:1)
- Free chlorine increases with dose, no free ammonia present. DBPs may form. (Cl₂:NH₄-N mass ratio above 7:1)

STABLE

UNSTABLE

FREE CHLORINE

Cl₂:NH₄-N mass ratio 5:1 7:1

STABLE

UNSTABLE

FREE CHLORINE
Question:
How do you know where you are on the breakpoint curve?

IF: Total Chlorine = 1.5 mg/L
AND Monochloramine = 1.2 mg/L
AND Free Ammonia = 0.4 mg/L
Maintaining a **stable chloramine residual** helps prevent nitrification.

**Total chlorine, monochloramine, and free available ammonia** must be measured to evaluate and control chloramine stability using the breakpoint curve. These three chemicals are referred to as the ‘chloramine-effectiveness’ group.

**Outline of webinar**

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. **What is Nitrification?**
4. Nitrification Action Plans
5. Assistance Opportunities
Nitrification is a natural biological process.

- Ammonia-oxidizing bacteria (AOB) eat ammonia and make nitrite ($\text{NO}_2^-$).
- Nitrite-oxidizing bacteria (NOB) eat nitrite ($\text{NO}_2^-$) and make nitrate ($\text{NO}_3^-$).

What is nitrification?

- Nitrification is a biological process.
  - It is natural.
  - It occurs in the environment and in pipes.
  - Just like algae, it can ‘bloom.’

- It causes loss of total chlorine and monochloramine residual in drinking water distribution systems.
  - This can result in coliform bacteria presence.
  - And other microbes, including pathogens.
What is nitrification?

Three perspectives:

• “Micro” view
  ▫ Looking at how bacteria work helps understand nitrification.

• “Macro” view
  ▫ Nitrification in the environment is different than nitrification in pipes.

• “PWS Data” view
  ▫ Analyzing data will tell you whether it is happening or not.
Every bacteria needs **energy** and **building blocks** to reproduce.

**Energy**

**BUILDING BLOCKS:**
Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous, Potassium, etc.

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**Getting to know AOB**

- **Ammonia Oxidizing Bacteria**
  - Nitrosomonas and other coliform bacteria.
  - AOB ‘eat’ ammonia (**NH₃**) for energy.
    - AOB ‘eats’ inorganic chemicals, so it is a ‘lithotroph,’ which means “rock eater.”
  - AOB ‘make’ nitrite (**NO₂⁻**).

$$
\text{NH}_3 + 1.5 \ O_2 \xrightarrow{A \otimes B} \text{NO}_2^- + 3\text{H}^+ + \text{H}_2\text{O} + \text{more bacteria}
$$
Getting to know NOB

- Nitrite Oxidizing Bacteria
  - Nitrobacter, and other coliform bacteria
  - They ‘eat’ nitrite ($\text{NO}_2^-$) for energy.
    - Nitrite is ‘inorganic’... most of the bacteria we are familiar with use ‘organic’ carbon, like sugar, for energy and building blocks.
  - They ‘make’ nitrate ($\text{NO}_3^-$)

\[
\text{NO}_2^- + \frac{1}{2} \text{O}_2 \xrightarrow{\text{NOB}} \text{NO}_3^- + \text{more bacteria}
\]
Note: AOB can drop pH

- Initial steps of nitrification can cause pH drop
  - \( \text{NH}_3 + 1.5 \text{O}_2 \rightarrow \text{AOB} \rightarrow \text{NO}_2^- + 3\text{H}^+ + \text{H}_2\text{O} \)
  - \( \text{pH} = -\log [\text{H}^+] \)
    - The pH level equals the negative log of hydrogen ion concentration.
    - For example: If \([\text{H}^+] = 10^{-6} \text{ moles/L}\)
      - Then \( \text{pH} = 6 \)
  - Impact of potential pH drop is greatest in water with low alkalinity, low buffer capacity.
    - More likely in East Texas than West Texas.
‘Macro’ view of nitrification

Nitrification in the environment

Wastewater effluent
Run off
Fish excreta and urine
Plant remnants

Nitrosomonas bacteria (AOB) uses up ammonia and makes NITRITE
Nitrobacter bacteria (NOB) uses nitrite to make NITRATE

AMMONIA
NITRITE (NO₂⁻)
NITRATE (NO₃⁻)
Gases
ANAEROBIC BACTERIA
PLANT FERTILIZER
Nitrification in a pipe

- **Nitrosomonas bacteria** (AOB) uses AMMONIA to produce NITRITE.
- **Nitrobacter bacteria** (NOB) uses NITRITE to produce NITRATE.

Reactions happen in biofilm.

- Naturally occurring
- Added
- Decomposition of chloramines

NITRITE (NO₂⁻)
NITRATE (NO₃⁻)

‘PWS Data’ view of nitrification
PWS monitoring data

- Data from sites representative of the distribution system:
  - Low, medium, high water age.
- At a minimum:
  - Total chlorine
  - Monochloramine
  - Free available ammonia
  - Nitrite (NO$_2^-$)
  - Nitrate (NO$_3^-$)

What can the data tell you?

Clues implying nitrification

- Chemical
  - Loss of chloramine residual
  - Disappearance of ammonia
  - Increase in nitrite or nitrate
    - And subsequent decrease in nitrite, and/or
  - pH decrease in low alkalinity waters
- Biological
  - Microbial regrowth, increased detection of
    - Coliform presence (TC+)
    - Heterotrophic plate count (HPC)
    - AOB/NOB increase
What can the data tell you?  
Clues implying nitrification

• A single result won’t tell you anything.
  ▪ Comparison helps you see connections.
    • Compare data from one site at multiple times = Trend analysis.
    • Compare data from one time at multiple sites = Mapping.

Data analysis example:  
PWS1 with no nitrification occurring
Data analysis example:
PWS1 with nitrification occurring

What can the data tell you?
How far has nitrification progressed?

• Initially:
  ▫ Ammonia will be lower than normal.
    • The AOB bugs are eating it.
  ▫ Nitrite will be higher than normal.
    • However, this is subtle when baseline nitrite is very low.
  ▫ Nitrate will be about the same as normal (baseline).
    • The NOB bugs are slower to start eating.

YMMV: Your mileage may vary.
Every system is different. Other progressions of microbial development may be observed.
**What can the data tell you?**

**How far has nitrification progressed?**

- When nitrification has progressed further:
  - Ammonia will be much lower than normal.
    - The AOB bugs are still eating it.
  - Nitrite will be higher OR lower OR normal.
    - The nitrite is simultaneously being formed and being eaten by NOB bugs.
  - Nitrate will be higher than normal (baseline).
    - The NOB bugs are eating the nitrite to form nitrate.
    - Some researchers have seen this stage of nitrification start sooner.

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**The nitrifiers (AOB and NOB) grow slowly**

![Graph showing the growth of nitrifiers over time](image-url)
Nitrification occurs in nature and in your pipes. It can ‘bloom’ in locations where the disinfectant is not able to overcome all of the bacteria.

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1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans
5. Assistance Opportunities
Outline: What makes a NAP?

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans
   4.a NAP map, sites, and schedules
   4.b List of Analytical Methods
   4.c Goals and Baselines and
   4.d Triggers
   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities

NAP map, sites, and schedules: Take-home message

- A map is the starting point for the NAP.
  - A good map shows: Sample sites, pipes, service area(s), pressure planes, entry points, tanks, and critical control points.
- A schedule ensures continuity of data.
Monitoring by location

- Follow the water (like Monitoring Plan):
  - **Raw water** (well taps are required)—to determine baselines for comparison with distribution.
  - **In-plant** (if treating)—to ensure stable monochloramine.
    - Before, during, and after chemical injection.
  - **Entry points**—to determine available ammonia, etc.
    - EP is the same as “Source” for purchased-water systems.
  - **Distribution**—to determine how water has degraded in transit measured at “representative” sites.

**Sample sites:** Follow the water:
Raw → Treatment → Entry point → Distribution
(Purchased-water: start at EP)

- **Wells & Raw surface water**
- **Treatment plants:**
  - wherever chloramines are injected
- **Entry points (EPs):**
  - wherever treated water enters the distribution system.
- **Distribution system:**
  - At locations representative of the entire system.
Raw water sampling

- Sample raw water to determine:
  - Is any free available ammonia present?
    - If so, this will impact how much ammonia to inject.
  - What are the baseline levels of nitrite and nitrate?
    - What is the natural level? This will be compared to the levels in distribution.

- (Purchased-water systems don’t have raw sources, so no raw-water sampling is generally needed.)

In-plant sampling

- The main purpose of sampling in the treatment plant is to determine if chemicals are injected correctly to accomplish treatment objectives.
  - Is stable monochloramine being formed?
  - Is ammonia sent to distribution limited as much as possible?

- (Systems with no treatment plants do not have to do in-plant sampling.)
Ideal chloramine dosing & monitoring

Inject chlorine  
Mix  
Measure chlorine

Inject ammonia  
Mix  
Measure total chlorine, monochloramine ammonia

Base ammonia dose on measured chlorine residual

Entry point (EP) sampling

- EP sampling purpose is:
  - Adequate initial residual?
    - Is the total chlorine residual high enough to keep stable chloramines throughout the system?
  - Is excess ammonia present?
    - Ammonia is ‘food’ for nitrifying bacteria (AOB).
  - What are the baseline levels of nitrite and nitrate?
    - For purchased-water systems, particularly, the levels of nitrite and nitrate will be compared to distribution levels to determine if either has grown.
Entry point (EP) sampling

- For purchased-water systems:
  - For systems that purchase and redistribute chloraminated water, sampling starts at the purchased-water entry points.
    - Many purchased-water systems have no EP tap.
    - Sampling at the first customer may not represent the water as delivered, if there is a long distance between them. **Consider installing a EP sample tap.**
Distribution sampling

- **Purpose 1: Distribution residual compliance.**
  - The purpose of daily/weekly **total chlorine** residual monitoring is to ensure compliant levels throughout the system.

- **Purpose 2: Chloramine stability.**
  - The purpose of required weekly monitoring for **monochloramine and ammonia** along with total chlorine is to make sure the chloramines are at the right ratio and nitrification is not occurring.

Distribution sample sites

- **Sites used for coliform monitoring** can be used (but that is not required).
  - Sites used for routine total chlorine monitoring **should** be used.

- **Critical control points**
  - Locations that provide critical information regarding potential nitrification.
    - Booster plants increase residual
    - Tanks increase water age
    - Historical problem areas
  - Consider dead-end main flushing locations and disinfection byproduct (DBP) sites.
**Question:** What does ‘representative of the entire distribution’ mean?

- Distribution sample sites must represent:
  - The entire distribution system:
    - Every pressure plane.
    - Low, medium, high, water age.
    - Including various high water age locations as needed.

- **Examples:**
  - Small systems~ 1 source, 1 pressure plane → 2-3 sites
  - Medium system~ 2 planes, 2 sources → 4-8 sites
  - Rule does not specify number, allows flexibility.
    - Recommendation = select critical control points.

**Question:** Are these sites representative?
(Population 500, one pressure plane)
What should be on your map?

- Roads.
- Pipes.
  - Down to a reasonable size. (‘skeletonized’).
- Service area boundary.
  - Often differs from utility, district, or city boundary.
  - Pressure planes, boundary and connections.
- Sources:
  - Wells, plants, purchased-water entry points.
- Tanks: In distribution. (Not plant clearwells.)
- Sample sites: With legible code or address.

Sample schedule

- The sample schedule requirements were discussed in detail in the TAWWA webinar presented on 10/7/16, and are described in the rules [30 TAC 290.110]
- The rules are the minimum regulatory requirement.

YMMV: Your mileage may vary. Every system is different. You may need to perform additional ‘process-management’ sampling to effectively detect nitrification.
Sample schedule efficiency

- Optimize your sampling schedule:
  - Collect your weekly **Mono** and **Ammonia** at the same time as a compliance sample:
    - Daily/weekly **Total** chlorine residual, or
    - Monthly coliform bacteria sample, or
    - Monthly dead-end main flushing sampling.
  - Use **Nitrite/Nitrate** compliance monitoring as part of baseline sampling:
    - TCEQ’s contractor (Antea) may be collecting these at entry point for you—review your chemical data.

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**Example: NAP Map & Schedule**

<table>
<thead>
<tr>
<th>Site # on Map</th>
<th>Address</th>
<th>Tap Type</th>
<th>Sample Tap Location</th>
<th>Flow Rate (gph)</th>
<th>Flash Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3F</td>
<td>281 Pump Station</td>
<td>hot bibb</td>
<td>May 281 Pump Station, top on Pump 1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>501 Oak St</td>
<td>hot bibb</td>
<td>Top by Cap Hall parking lot</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>501 N. Jackson</td>
<td>hot bibb</td>
<td>Top at back of house</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>501 N. Illinois</td>
<td>hot bibb</td>
<td>County Fire Department top side water main</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>800 N. Maple</td>
<td>hot bibb</td>
<td>Top left of front door of High School</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>701 Badger Blvd</td>
<td>hot bibb</td>
<td>Left side of garage</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>3rd St.</td>
<td>hot bibb</td>
<td>Top near west of CSO</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>5th St.</td>
<td>hot bibb</td>
<td>Back of house by back door</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>5th St.</td>
<td>hot bibb</td>
<td>First Memorial Church, top left of door</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>
### Nitrification Action Plan Example

#### Chloramine-Effectiveness Sample Suite

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Goal</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total / Mono</td>
<td></td>
<td>Trigger</td>
<td>Actions</td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP001</td>
<td>Total / Mono</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4357 2nd Ave</td>
<td>Total / Mono</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11500 IH35 N</td>
<td>Total / Mono</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Nitrite/Nitrate

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Baseline</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrite</td>
<td></td>
<td>Trigger</td>
<td>Actions</td>
</tr>
<tr>
<td></td>
<td>Nitrate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NAP map, sites, and schedules:

**Take-home message**

- Sample sites ‘follow the water.’
- A map is the starting point for the NAP.
  - A good map shows: Sample sites, pipes, service area(s), pressure planes, entry points, tanks, and critical control points.
- A schedule ensures continuity of data.
Outline of webinar

1. History of Nitrification in Texas
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   4.a NAP map, sites, and schedules
   4.b Analytical Methods and List of Analytical Methods (LAM)
   4.c Goals and Baselines and
   4.d Triggers
   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities

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Analytical Methods for the NAP: Take-home message

Accurate sampling gives you good data to manage your system.

Methods need to be able to detect small changes in concentration.

Methods should be listed on the NAP List of Analytical Methods (LAM).
Analytical Methods [§290.110(d)]

- Total chlorine:
  - Use EPA approved method
- Monochloramine and ammonia:
  - Meet TCEQ accuracy standards.
    - There are no EPA-approved methods for ammonia and monochloramine, since EPA does not regulate them.
- Nitrite and nitrate:
  - TCEQ requires that analysis meet accuracy standards.
  - EPA methods are available, but are not required.
    - EPA methods are not required because measurements in distribution are not intended to determine compliance with nitrite or nitrate maximum contaminant levels (MCLs).

Accuracy Requirements [§290.110(d)]

<table>
<thead>
<tr>
<th>Test</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Chlorine (as Cl₂)</td>
<td>(+/-) 0.1 mg/L</td>
</tr>
<tr>
<td>Free Chlorine (as Cl₂)</td>
<td>(+/-) 0.1 mg/L</td>
</tr>
<tr>
<td>Monochloramine (as Cl₂)</td>
<td>(+/-) 0.15 mg/L</td>
</tr>
<tr>
<td>Free Ammonia (as N)</td>
<td>(+/-) 0.1 mg/L</td>
</tr>
<tr>
<td>Nitrate (as N)</td>
<td>(+/-) 0.1 mg/L</td>
</tr>
<tr>
<td>Nitrite (as N)</td>
<td>(+/-) 0.01 mg/L</td>
</tr>
</tbody>
</table>

*a Must have the ability to distinguish between monochloramine and other forms of total chlorine.

*b Samples results must be provided within 48 hours of sample delivery.
Analytical Methods [§290.110(d)]

- **Field Instruments:**
  - Instruments must be calibrated/verified every 90 days.
  - Keep records of calibration/verification on file!
    - “If it’s not documented, it’s not done!”
- Be prepared to document the accuracy of any laboratory-analyzed samples.

Documenting Analytical Methods

- NAP List of Analytical Methods (LAM) is used to document methods.
  - TCEQ’s Lab Approval Form (LAF)—a required attachment to the Monitoring Plan—does not currently have sections for monochloramine, ammonia, nitrate, and nitrite.
  - A sample LAM is included in the NAP Template. The spreadsheet is available for download on the TCEQ website.
List of Analytical Methods

• The LAM does not need to be submitted to the TCEQ for approval.
  ▫ Keep your LAM with the system’s NAP, attached to your Monitoring Plan.
  ▫ Make it available to the TCEQ upon request.
• Change your NAP LAM as needed to reflect your procedures.
  ▫ Any changes to your LAM do not need TCEQ approval.

A lamb nap, not a NAP LAM
### List of Analytical Methods (LAM) for Monitoring Chloramines

You must document the methods and laboratories on this List of Analytical Methods (LAM).

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Analytical Method</th>
<th>Instrument Name</th>
<th>Accuracy</th>
<th>Calibration Frequency</th>
<th>Calibration Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochloramine</td>
<td>Document the accuracy that your selected method can achieve.</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Ammonia (as N)</td>
<td></td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrite (as nitrogen)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate (as nitrogen)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other NAP Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>pH unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td>C or F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkalinity</td>
<td></td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td></td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterotrophic plate count bacteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial DNA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Document the make and model of the instrument you are using to measure the analyte.

Report the number of decimal places to which you can accurately report the value for each analyte. For a list of analytical requirements, please see §290.110(d).

Report the frequency and method with which you calibrate or verify the accuracy of your equipment.

### List of Analytical Methods, cont’d.

#### NAP Required Parameters (AKA Analytes, Constituents, etc.)

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Analytical Method</th>
<th>Instrument Name</th>
<th>Accuracy</th>
<th>Calibration Frequency</th>
<th>Calibration Method</th>
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<td>mg/L</td>
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<td></td>
<td></td>
</tr>
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<td></td>
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<td></td>
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<td></td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>pH unit</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Note:** Nitrate and nitrite sampling: Field or lab analysis?

- PWSs must obtain equipment for field-measurement of nitrate and nitrite, OR an accredited lab can be used.
  - If samples are sent to a lab, the lab MUST be accredited for drinking water.
    - The lab’s method must be EPA-approved, AND meet TCEQ accuracy standards.
    - The lab must be able to provide results to PWS within 48 hours.

**Available field instruments**

<table>
<thead>
<tr>
<th>Instrument: Manufacturer and Instrument #</th>
<th>Free Ammonia ±0.1 mg/L</th>
<th>Mono-chloramine ±0.15 mg/L</th>
<th>Nitrate ±0.1 mg/L</th>
<th>Nitrite ±0.01 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hach Pocket Colorimeter II w/ Hach MTD 10200</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hach Pocket Colorimeter II w/ Hach MTD 8039 (Total Nitrate)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hach DR 800 Series, DR900 w/ Hach MTD 8192</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hach DR 800 Series, DR900 w/ Hach MTD 8507 *</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hach DR 1900, 2800, 3800, 3900, 5000, 6000 w/ Hach MTD 10206</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hach DR 1900, 2800, 3800, 3900, 5000, 6000 w/ Hach MTD 10207</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

* EPA approved for wastewater
Available field instruments, cont’d.

<table>
<thead>
<tr>
<th>Instrument: Manufacturer and Instrument #</th>
<th>Free Ammonia ±0.1 mg/L</th>
<th>Mono-chloramine ±0.15 mg/L</th>
<th>Nitrates ±0.1 mg/L</th>
<th>Nitrites ±0.01 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orion ISE meter and probe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orion Aquafast AQ4000 w/ Orion MTD AC2046 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orion AQ3700</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orion AQ3700**</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>LaMotte 7-2000-UV</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LaMotte Smart 3</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LaMotte Smart Spectro</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hanna HI 96707</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Hanna HI 96796 (Total Nitrate)</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

November 17, 2016

Instrumentation notes, based on questions we have received.

- Hach 800 or 900 series colorimeter?
  - Can be used for total chlorine, monochloramine, free ammonia, nitrite, and nitrate.
- Hach SL 1000? (“keys”)
  - Can be used for total chlorine, monochloramine, free ammonia (N), and nitrite
     - ‘Keys’ are available.
  - No ‘keys’ for nitrate:
     - A nitrate probe is available for the SL1000.
     - It costs ~ $800.

November 17, 2016
Accurate sampling gives you good data to manage your system.
Methods need to be able to detect small changes in concentration.
Methods should be listed on the NAP List of Analytical Methods (LAM).

Outline of webinar

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans:
   4.a NAP map, sites, and schedules
   4.b Analytical Methods and LAM
   4.c Goals and Baselines
   4.d Triggers
   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities
Goals and baselines are the **normal operating ranges** for the system.

- **Goals** are the desired levels of total chlorine, monochloramine, and ammonia that the PWS controls.
- **Baselines** are the normally anticipated levels of nitrite, nitrate (and other things) that are *not controllable* by the system, but can impact and/or be a clue in detecting nitrification.

### Baselines and Goals

- **Baselines**—not under a system’s control.
  - Normal levels of source nitrite/nitrate.
  - Entry-point ammonia for purchased-water.
- **Goals**—things that the system controls.
  - Total/mono/ammonia: Normal, good levels.
    - Ensure stable monochloramine is maintained.
  - Targets are set at entry points and at sites throughout the distribution system.

Basically, the levels that make you feel comfortable that things are normal and running right.
Goals: For each sample site...

1. Look at historical data, and determine range of levels and variability (“noise”).
   a. Select data when levels are **good**—compliant residuals, stable monochloramine, **normal**.
   b. Evaluate **range** of selected data—max and min.
   c. Determine **variability** of data—look at how much levels differ from the norm (standard deviation).

2. **Choose** your goals for each specific site:
   a. Total chlorine/monochloramine.
   b. Free available ammonia.

Goals for each site: Total/Mono/Ammonia

- If you don’t have data, get some immediately.
  - Goals for Total/Mono/Ammonia will be different across the system:
    - Total and monochloramine goals will decrease.
    - Ammonia ‘goal’ will increase from almost zero.

<table>
<thead>
<tr>
<th>Total Chlorine</th>
<th>Monochloramine</th>
<th>Free Available Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set Entry Point goal high enough to get Total Chlorine to end of distribution system.</td>
<td>Ideally, <strong>Total = Mono</strong>. Therefore, use the same goals for total chlorine and for monochloramine.</td>
<td>Free available ammonia will increase through distribution under normal conditions.</td>
</tr>
<tr>
<td>Set high-water age levels over minimum (0.5 mg/L).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

November 17, 2016
Baselines: For all sources...
Raw and purchased sources

1. Look at historical data, determine range of levels (max and min), and variability (“noise”).
   a. Select ALL data, NOT just when levels are good.
   b. Evaluate the data, consider the standard deviation (how much do levels differ from the norm).

2. Identify your baselines:
   a. Nitrate: Consider the highest observed level, or one standard deviation above average, to be the baseline
   b. Nitrite: Consider the range from max to min. Set high and low baselines.
   c. Ammonia:
      - Purchased chloraminated water contains ammonia.
      - Wells with ammonia will need special attention.

Baselines for each source:
Nitrite, nitrate

- If you have historical data, evaluate it and extract the data of interest.
  - If you don’t, start sampling. Estimate your baselines using initial results. Plan to revise baselines.

<table>
<thead>
<tr>
<th>Nitrite baseline</th>
<th>Nitrate baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrite should <strong>not change</strong> if nitrification is not happening. The nitrite level at all locations in distribution should be within a range of the baseline, always.</td>
<td>Nitrate will <strong>stay constant</strong> unless there is nitrification. The nitrate level in distribution should be the same as baseline, always.</td>
</tr>
</tbody>
</table>
Free Available Ammonia

- Raw source ammonia:
  - Source water ammonia may indicate contamination.
  - A system with ammonia in their wells may not even realize they are chloraminating.
- Purchased-water ammonia:
  - Ammonia from purchaser may vary:
    - Depending on the source they are using.
    - Depending on treatment changes.
  - Checking frequently is highly recommended.
    - In order to respond appropriately.

Free Available Ammonia baseline for purchased-water sources

- Managing purchased-water chloramines is a special challenge.
  - Total/Mono/Ammonia levels entering the system are outside of the purchaser’s control.
  - If the purchased-water is ‘old’ it can have very high levels of ammonia.
    - Or low levels of ammonia if nitrification is already occurring prior to entry point location.
  - Ammonia is food for AOB nitrifying bacteria.
Example: Normal conditions
(no nitrification occurring)

Normal conditions at site #2, for a given date and time.

Example: Setting goals for Site 2
• Gather data for just that site.

SITE 2: 4691 2nd Ave.

<table>
<thead>
<tr>
<th></th>
<th>1/2/16</th>
<th>1/9/16</th>
<th>1/16/16</th>
<th>1/23/16</th>
<th>1/30/16</th>
<th>2/6/16</th>
<th>2/13/16</th>
<th>2/20/16</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2.82</td>
<td>3.00</td>
<td>2.90</td>
<td>2.60</td>
<td>2.65</td>
<td>2.90</td>
<td>3.00</td>
<td>2.70</td>
<td>2.82</td>
</tr>
<tr>
<td>Mono</td>
<td>2.60</td>
<td>2.65</td>
<td>2.71</td>
<td>2.40</td>
<td>2.50</td>
<td>2.90</td>
<td>2.80</td>
<td>2.61</td>
<td>2.65</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.64</td>
<td>0.80</td>
<td>0.65</td>
<td>0.71</td>
<td>0.76</td>
<td>0.73</td>
<td>0.61</td>
<td>0.71</td>
<td>0.70</td>
</tr>
<tr>
<td>Nitrite</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.0010</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.34</td>
<td>0.2</td>
<td>0.3</td>
<td>0.31</td>
<td>0.29</td>
<td>0.3</td>
<td>0.36</td>
<td>0.3</td>
<td>0.30</td>
</tr>
</tbody>
</table>
**Example: Setting goals for Site 2**

- Graph data for just that site.

![Graph showing data for Site 2.](image)

**Example: Setting goals for Site 2**

- Consider each analyte individually.

![Graph showing total chlorine for Site 2.](image)

<table>
<thead>
<tr>
<th>Date</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2/16</td>
<td>2.82</td>
</tr>
<tr>
<td>1/9/16</td>
<td>3.00</td>
</tr>
<tr>
<td>1/16/16</td>
<td>2.90</td>
</tr>
<tr>
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<td>2.60</td>
</tr>
<tr>
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<td>2.65</td>
</tr>
<tr>
<td>2/6/16</td>
<td>2.90</td>
</tr>
<tr>
<td>2/13/16</td>
<td>3.00</td>
</tr>
<tr>
<td>2/20/16</td>
<td>2.70</td>
</tr>
</tbody>
</table>
Example: Setting goals for Site 2

- Get min, max, average, and standard deviation.

<table>
<thead>
<tr>
<th>Date</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2/16</td>
<td>2.82</td>
</tr>
<tr>
<td>1/9/16</td>
<td>3.00</td>
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<td>2.65</td>
</tr>
<tr>
<td>2/6/16</td>
<td>2.90</td>
</tr>
<tr>
<td>2/13/16</td>
<td>3.00</td>
</tr>
<tr>
<td>2/20/16</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Min 2.60
Max 3.00
Average 2.82
Standard deviation (SD) 0.16
Average + 2 SD 3.14
Average - 2 SD 2.50

- Select minimum total chlorine trigger.

### Nitrification Action Plan Example

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Goal</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP001</td>
<td>Total / Mono</td>
<td>4.0</td>
<td>Trigger</td>
<td>Actions</td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4357 2nd Ave</td>
<td>Total / Mono</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.3 - 0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11500 IH35 N</td>
<td>Total / Mono</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.6 - 0.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Nitrite/Nitrate

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Baseline</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites</td>
<td>Nitrite</td>
<td>0.1 - 0.15</td>
<td>Trigger</td>
<td>Actions</td>
</tr>
<tr>
<td></td>
<td>Nitrate</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Goals and baselines are the normal operating ranges for the system.

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   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities
4.d. Triggers: Take-home message

Triggers are the levels that call you to action.

- Yellow flag triggers call you to a minor change of action—more sampling, slight dose changes, flushing, etc.
- Red flag triggers call you to greater action, hopefully before compliance or public health is at risk.

Baseline (Green light→ Go!)
Parameters in normal operating range – all systems 'go.'

Alert (Yellow flag→ Act.)
Outside normal operating range – take precautions.

Alarm! (Red flag→ Act!!!)
Too far outside normal operating range – take immediate action!
Triggers

- **Normal levels—routine operation**
  - All is going well.

- **Yellow Flag Trigger**
  - Somewhat out of the norm.
  - Indicating nitrification may have started.

- **Red Flag Triggers**
  - When it becomes difficult to maintain a compliant total chlorine residual.
  - Strong possibility that nitrification is the culprit.
    - Or at least that possibility needs to be evaluated.

Setting Triggers

- If you have data from a nitrification event, evaluate it and extract the data of interest.
- If you don’t, then estimate your triggers.

- **Total Chlorine**
  - Use data from past nitrification events (if possible).

- **Mono-chloramine**
  - Ideally, Total = Mono.
  - Use total chlorine triggers.

- **Free Ammonia**
  - Free available ammonia will decrease during nitrification.

- **Nitrite**
  - Nitrite may increase or decrease.
  - Start = increase.
  - Later = decrease.

- **Nitrate**
  - Increases when nitrification is really bad.
Triggers for nitrite and nitrate

- If you have historical data, evaluate it and extract the data of interest.
  - If you don’t, start sampling. Estimate your triggers using initial results. Plan to revise triggers if needed.

### Nitrite triggers
- Nitrite may increase or decrease.
  - Start = increase.
  - Extensive nitrification = decrease. Concentrations are often very low, which can make trend analysis harder.

### Nitrate triggers
- Nitrate increases when nitrification is really bad.
  - Example: Baseline +20% Baseline +40%

Triggers at each site type

- If you have data from a nitrification event, evaluate it and extract the data of interest.
  - If you don’t, then estimate and revise triggers.

<table>
<thead>
<tr>
<th>Total Chlorine</th>
<th>Monochloramine</th>
<th>Free Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry point trigger: High enough to reach the end of distribution.</td>
<td>Total chlorine and monochloramine triggers can be the same.</td>
<td>Free available ammonia will decrease during nitrification. Normal ammonia will be lower at EPs, higher at high water age. Set triggers at low, average, and high water age sites.</td>
</tr>
<tr>
<td>High water age site trigger: Don’t go below the regulatory minimum + safety factor.</td>
<td>Set triggers at low, average, and high water age sites.</td>
<td></td>
</tr>
</tbody>
</table>
Yellow flag triggers

• Values are starting to deviate from the norm.
  ▫ It may be a temporary thing—but let’s double check!
  ▫ At entry point/low water age sites:
    • Total chlorine: Will this residual reach all points?
    • Ammonia: Is this as low as I can make it?
  ▫ Average water age sites:
    • Is this abnormal?
  ▫ At high water age sites:
    • Total chlorine:
      • How far is it off the system’s overall goal?
    • Ammonia:
      • Is this as high as usual? Or is something eating it up.
        ▪ (Dilute samples if it is flashing *0.55*)
Red flag triggers

• Values are far from the norm. Action is needed.
  ▪ Often, the situation is an area with low total chlorine residual.
  ▪ Determine whether nitrification is the problem.
    • At entry point/low water age sites:
      • Total chlorine: Is the EP residual too low to reach all points?
      • Ammonia: Am I over the breakpoint?
    • Average water age sites:
      • Is this abnormal? Is the problem isolated in distribution?
    • At high water age sites:
      • Total chlorine: Is the level approaching the minimum?
      • Ammonia: Is this gone? If so, there’s your smoking gun.

Red flag triggers

• Values are far from the norm. Action is needed.
  ▪ Nitrite and nitrate need to be checked more than normal.
    • If nitrite or nitrate deviates a lot, something is wrong.
      • Check in multiple locations.
    • For example (use your own data):
      • Nitrite outside 2 standard deviations, 20%, +/- 0.005 mg/L
      • Nitrate increase over 2 standard deviations, 20%, +0.25 mg/L
### Nitrification Action Plan Example

**Chloramine-Effectiveness Sample Suite**

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Goal</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Trigger</td>
<td>Actions</td>
<td>Trigger</td>
</tr>
<tr>
<td>EP001</td>
<td>Total / Mono</td>
<td>4.0</td>
<td>&lt; 3.5, &gt; 4.2</td>
<td>&lt; 3.0, &gt; 4.5</td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.3</td>
<td>&lt; 0.2</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>4357 2nd Ave</td>
<td>Total / Mono</td>
<td>2.0</td>
<td>&lt; 1.5</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.3 – 0.4</td>
<td>&lt; 0.3</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>11500 IH35 N</td>
<td>Total / Mono</td>
<td>1.0</td>
<td>&lt; 1.0</td>
<td>&lt; 0.7</td>
</tr>
<tr>
<td></td>
<td>Free ammonia</td>
<td>0.6 – 0.8</td>
<td>&lt; 0.5</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Nitrite/Nitrate</th>
<th>Trigger</th>
<th>Actions</th>
<th>Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrite</td>
<td>0.1 – 0.15</td>
<td>&lt; 0.1, &gt; 0.15</td>
<td>0, &gt; 0.25</td>
</tr>
<tr>
<td></td>
<td>Nitrate</td>
<td>0.8</td>
<td>&gt; 0.8 + SD</td>
<td>&gt; 0.8 + 2SD</td>
</tr>
</tbody>
</table>

### 4.d. Triggers:

**Take-home message**

Triggers are the levels that call you to action.

- **Yellow flag** triggers call you to a minor change of action—more sampling, slight dose changes, flushing, etc.
- **Red flag** triggers call you to greater action, hopefully before compliance or public health is at risk.
Outline of webinar

1. History of Nitrification in Texas
2. Chloramine Chemistry Review
3. What is Nitrification?
4. Nitrification Action Plans:
   4.a NAP map, sites, and schedules
   4.b Analytical Methods and LAM
   4.c Goals and Baselines
   4.d Triggers
   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities

4.e Actions: Take-home message

Response actions may be the same as routine preventive actions: for example—flushing. Some actions provide more data to learn about the situation: for example—verification sampling, nitrite/nitrate sampling. Some actions correct an issue: for example—flushing, tank cleaning, temporary conversion to free-chlorine (“burn”).
Corrective Actions

- Normal Operations
  - If all is going well, preventive actions help keep it that way.

- Yellow Flag Corrective Actions
  - Some action is needed to get back to normal.
  - Often similar to preventive actions.

- Red Flag Corrective Actions
  - More extreme measures are needed to get back on track.

Examples of Yellow Flag Alert Corrective Actions

- Sample Verification:
  - Double check measurements before making a decision (especially total/mono/ammonia).
  - Check the nearby area for range of abnormal results (upstream/downstream).

- Look for leaks or hazards:
  - A cross connection can cause similar symptoms to nitrification.
Examples of Yellow Flag Alert Corrective Actions

- Nitrite/Nitrate Sampling:
  - Nitrite/Nitrate changes can indicate nitrification.
- Nitrite~can be tricky:
  - Levels usually start very low.
    - For nitrite to be a useful indicator, results must be above method detection limit.
  - It can go up OR down depending on extent of nitrification.
- Nitrate:
  - If it goes up, there’s a problem.

- Flushing:
  - Short term, but will help bring fresh water with a strong residual to affected area.
- Storage Tank Operation & Maintenance:
  - Optimize tank operations to minimize water age.
- Treatment plants:
  - Adjust dose.
- Purchased-water systems:
  - Contact seller if unusual results are seen at the purchased-water entry point.
Examples of Red Flag Alarm Corrective Actions

• Same actions as Yellow Flag Alert actions.
  ▫ All of the same double checking, follow-up sampling, and flushing can be used to various degrees.

• Unidirectional flushing (UDF)
  ▫ More extreme than normal flushing.
    • Purpose: Get the water velocity to at least 5 ft/sec to re-suspend and remove sediment that can harbor nitrifying bacteria.

Examples of Red Flag Alarm Corrective Actions

• Free Chlorine Conversion (a.k.a. burn): To starve nitrifying bacteria.
  ▫ Contact TCEQ before conversion.
    • DBP@tceq.texas.gov

• Disclaimer: If nitrification can’t be controlled by your NAP, engineered modifications may be required. For example:
  ▫ Booster disinfection
  ▫ pH adjustment
  ▫ Looping mains
### Nitrification Action Plan Example

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Goal</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Trigger</td>
<td>Actions</td>
<td>Trigger</td>
</tr>
</tbody>
</table>
| EP001      | Total / Mono | 4.0 | < 3.5, > 4.2 | 1) Verify results.  
2) Check and adjust dose.  
3) Contact wholesaler.  
|            | Free ammonia | 0.3 | < 0.2, > 0.4 | 1) Verify results.  
2) Adjust dose. |
| 4357 2nd Ave | Total / Mono | 2.0 | < 1.5 | 1) Verify results.  
2) Measure nitrite and nitrate.  
3) Adjust dose.  
|            | Free ammonia | 0.3 – 0.4 | < 0.3 | 1) Verify results.  
2) Measure nitrite and nitrate.  
3) Adjust dose.  
4) Identify affected area (check upstream and downstream).  
5) Flush area.  
6) Flush dead ends.  |
| 11500 IH35 N | Total / Mono | 1.0 | < 1.0 | 1) Verify results.  
2) Measure nitrite and nitrate.  
3) Adjust dose.  
4) Identify affected area (check upstream and downstream).  
5) Flush area.  
6) Flush dead ends.  
|            | Free ammonia | 0.6 – 0.8 | < 0.5 | 1) Verify results.  
2) Measure nitrite and nitrate.  
3) Adjust dose.  
4) Identify affected area (check upstream and downstream).  
5) Flush area.  
6) Flush dead ends.  
7) Free Chlorine Conversion. |

### Nitrite/Nitrate

<table>
<thead>
<tr>
<th>Site</th>
<th>Chemical</th>
<th>Baseline</th>
<th>Trigger</th>
<th>Yellow Flag</th>
<th>Red Flag</th>
</tr>
</thead>
</table>
|      | Nitrite  | 0.1 – 0.15 | < 0.1, > 0.15 | 1) Verify results.  
2) Identify source water changes.  
3) Modify baseline if confirmed.  
4) Contact wholesaler.  
|      | Nitrate  | 0.8 | > 0.8 + SD | 1) Verify results.  
2) Identify affected area.  
3) Flush.  
4) Free Chlorine Conversion. |

### 4.e Actions: Take-home message

Response actions overlap with normal, preventive actions. The more severe the situation, the more extensive the response.

Some actions find clues to evaluate the situation: special studies, sampling.

Some actions fix the immediate issue: flushing, tank cleaning, free-chlorine conversion, etc.
Outline of webinar

1. History of Nitrification in Texas
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   4.b Analytical Methods and LAM
   4.c Goals and Baselines
   4.d Triggers
   4.e Corrective Actions
   4.f Communication!
5. Assistance Opportunities

4.f The 3 Cs: Take-home message

Communication, coordination, and cooperation (The 3 Cs) makes everything work better and keeps everyone on the same team.

• Internal communication, like reporting and training, makes your organization successful.
• External communication, like working with TCEQ, helps a PWS stay in compliance.
Communication

• Make sure that the people who have a role in implementing the NAP are aware and ready.
  ▫ Consider WHO needs to take action.
  ▫ Make sure they have instructions (SOP).
  ▫ Make sure they know WHOM they need to contact to make things happen (management).

• When people are surprised, things can go wrong!
  • Communication minimizes surprises.
  • Internal communication is needed to make sure the PWS takes the right actions.
  • External communication is needed to make sure the TCEQ/downstream systems/customers know what is going on.
Internal - Standard Operating Procedures (SOPs)

- SOPs are instructions on how to do a task.
  - Written SOPs help give staff direction in performing their tasks.
  - Would a new hire know what to do?
- Ensure consistency and accuracy.
  - Consistent, accurate data supports good decisions.
- Captures chain of communication.
  - Is permission needed to do a task or operation?

Internal - Training

- Periodic training helps staff feel comfortable that they are doing their task correctly.
- Help update staff on any operational changes.
- Refreshers!
External - Communication

- Your customers
  - Ex: Chlorine Conversion – need to notify your customers and wholesale customers.
  - Could Public Relations help?
- Laboratories
  - Emergency situations where you need a lab.
- TCEQ
  - Contact us before you do a free chlorine conversion.
    - DBP@tceq.texas.gov
  - Boil Water Notice – Contact Central Office and your TCEQ Regional Office.

4.f The 3 Cs: Take-home message

Communication, coordination, and cooperation (the 3 Cs) makes everything work better and keeps everyone on the same team.

- **Internal** communication, like reporting and training, makes your organization successful.
- **External** communication, like working with TCEQ, helps a PWS stay in compliance.
Outline of webinar

1. History of Nitrification in Texas
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3. What is Nitrification?
4. Nitrification Action Plans
5. Assistance Opportunities

There is help!
TCEQ offers free, on-site technical assistance to help you with your NAP.
You are not alone.
Assistance is available

• TCEQ Small Business and Local Government Assistance
  ▫ Enviromentor Program
• TCEQ Financial, Managerial, and Technical (FMT) Program
  ▫ Texas Rural Water Association contractors
• Texas Optimization Program (TOP)
• Associations, consultants, other PWSs, etc.

TCEQ Financial, Managerial, and Technical (FMT) Program

• Various types of assistance are available.
  ▫ All are free and held at your office or plant.
• Targeted assistance:
  ▫ Select the topics you need help with from the assistance request form.
    • One-on-one, informal, site-specific technical help.
• Direct Assistance Modules (DAMs)
  ▫ Free, at your location.
  ▫ Workshop using your data.
  ▫ Continuing Education Units (CEUs) can be assigned.
Directed Assistance Modules (DAMs)

- Chloramines DAM
  - This DAM includes the chemistry, but also helps with dosing and analysis calculations.
  - Recommended for all PWSs with chloramines.
- Nitrification Action Plan (NAP) DAM
  - This DAM is a table-top workshop using your data. After completing this DAM, you should be halfway done with your NAP... or further.
  - Recommended for all PWSs with chloramines.

TCEQ FMT Program

Call (512) 239-4691
and ask to speak to staff with the FMT Program

or

Send an email to FMT@tceq.texas.gov
External references for the enthusiastic student

- TCEQ website:


There is help!
TCEQ offers free, on-site technical assistance to help you with your NAP.

Call (512) 239-4691 and ask for the FMT Assistance Program or email FMT@tceq.texas.gov.
NAPs
Overall Take Home Message

A NAP is a tool to help you avoid and respond to nitrification. It is specific to your system.

Establishing key levels and triggers can help you catch nitrification before it blooms. Use good data that accurately captures your system.

The best NAP in the world is useless if it sits on a shelf. Communicate, coordinate, and cooperate!

Thanks!

Questions?
Presenter contact information

• Alicia Diehl, P.E. Ph.D.
  ◦ Altamira Water LLC, TCEQ contractor
  ◦ Alicia.Diehl@tceq.texas.gov
  ◦ 512-239-4691
• David Simons, P.E., TCEQ WSD
  ◦ David.Simons@tceq.texas.gov
  ◦ 512-239-4691
• Yadhira A. Resendez, E.I.T., M.S.E, TCEQ WSD
  ◦ Yadhira.Resendez@tceq.texas.gov
  ◦ 512-239-4691

Bonus slides
The NAP rule language:

290.46(z) Nitrification Action Plan (NAP). Any water system distributing chloraminated water must create a NAP. The system must create a written NAP that:

- (1) contains the system-specific plan for monitoring free ammonia, monochloramine, total chlorine, nitrite, and nitrate levels;
- (2) contains system-specific action levels of the above monitored chemicals where action must be taken;
- (3) contains specific corrective actions to be taken if the action levels are exceeded; and
- (4) is maintained as part of the system's monitoring plan in §290.121 of this title.

Overview of required sample schedule

<table>
<thead>
<tr>
<th>Routine Monitoring</th>
<th>At or After the Entry Point(s)</th>
<th>Upstream and Downstream of Any Chlorine or Ammonia Injection Points</th>
<th>In the Distribution System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Chlorine</td>
<td>At least weekly.</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
<td>Daily / weekly.</td>
</tr>
<tr>
<td>Free Ammonia</td>
<td>At least weekly.</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
<td>At least weekly.</td>
</tr>
<tr>
<td>Monochloramine</td>
<td>At least weekly.</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
<td>At least weekly.</td>
</tr>
<tr>
<td>Nitrite and Nitrate</td>
<td>Monthly for at least 6 months to set baseline, then quarterly</td>
<td>Routine sampling not required. (May be part of a Nitrification Action Plan.)</td>
<td>At least quarterly, and in response to action level triggers.</td>
</tr>
</tbody>
</table>
**Ammonia: Sample schedule**

**One-Time Source Water Monitoring Requirement:**
Ammonia Baselines for each source

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Frequency at each source (including purchased water take points)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ammonia</strong> (as nitrogen)</td>
<td><strong>Once or more</strong> to determine the availability of source water ammonia for chloramine formation.</td>
</tr>
<tr>
<td></td>
<td>• If source has more than 0.5 mg/L free ammonia (as N), monitor <strong>monthly for six months</strong> to establish baseline.</td>
</tr>
<tr>
<td></td>
<td>• Knowing the incoming ammonia will keep you from overdosing ammonia when treating.</td>
</tr>
<tr>
<td></td>
<td>• If levels are variable, additional sampling is highly recommended</td>
</tr>
</tbody>
</table>

*If you have already completed this source water monitoring in the past and have the results, there is no requirement to take new samples.

---

**Nitrite/Nitrate: Sample schedule**

**Baselines**

**Baseline determination:**

<table>
<thead>
<tr>
<th>If you don't have a baseline:</th>
<th><strong>Monthly</strong> for six (6) months at each entry point*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Or use quarterly compliance samples, if present.</td>
</tr>
<tr>
<td></td>
<td>(Or more sampling if needed/wanted)</td>
</tr>
</tbody>
</table>

**On-going monitoring:**

<table>
<thead>
<tr>
<th>After a baseline is set:</th>
<th><strong>Quarterly</strong> at each entry point *.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quarterly in distribution—at representative sites where total/mono/ammonia are collected</td>
</tr>
</tbody>
</table>

**As part of Nitrification Action Plan:**

<table>
<thead>
<tr>
<th>As a response action:</th>
<th>If other sampling triggers response actions.</th>
</tr>
</thead>
</table>

*Entry point samples may be collected at entry point sample site, or first customer. Dedicated EP sample site is recommended.
Treatment sampling schedule—before and after chemical injection

<table>
<thead>
<tr>
<th></th>
<th>Upstream and Downstream of Any Chlorine or Ammonia Injection Points *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Chlorine</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
</tr>
<tr>
<td>Free Ammonia</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
</tr>
<tr>
<td>Monochloramine</td>
<td>Weekly and before and after adjusting the chlorine or ammonia feed rate.</td>
</tr>
<tr>
<td>Nitrite and Nitrate</td>
<td>Routine sampling not required. (May be part of a Nitrification Action Plan.)</td>
</tr>
</tbody>
</table>

* Plants built before 2016 with no sample ports are ‘grandfathered.’ Retrofit is recommended, not required.

Total Chlorine, Monochloramine and Ammonia Schedule

<table>
<thead>
<tr>
<th>Entry Point(s)</th>
<th>At representative sites in the Distribution System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Chlorine</td>
<td>At least weekly. Daily / weekly (Over pop 750 = daily)</td>
</tr>
<tr>
<td>Monochloramine</td>
<td>At least weekly. At least weekly.</td>
</tr>
<tr>
<td>Free Ammonia</td>
<td>At least weekly. At least weekly.</td>
</tr>
</tbody>
</table>