TEXAS OPTIMIZATION PROGRAM (TOP)
DIRECTED ASSISTANCE MODULE (DAM) 8

HOW TO CREATE A NITRIFICATION ACTION PLAN (NAP) FOR A PUBLIC WATER SYSTEM (PWS) USING CHLORAMINES

STUDENT GUIDE

TCEQ Course # 1446

Latest revision date: June 25, 2019

Notes

Contents

Definitions

Ammonia-oxidizing bacteria (AOB): Bacteria that convert free available ammonia to nitrite.

Average: A number expressing the central or typical value in a set of data, most commonly the mean, which is calculated by dividing the sum of the values in the set by their number.

Autotroph: An organism that uses simple inorganic substances such as carbon dioxide for nutrition.

Biofilm: A thin layer of bacteria adhering to pipe walls, ranging from one-bacteria thick to inches, depending on the conditions in the pipe.

Denitrification: In wastewater treatment, a process used to intentionally transform nitrogen-containing molecules to nitrogen (N_2) through a series of intermediate nitrogen oxide products.

Flush: To force water through pipes at accelerated flow in order to bring 'fresh' water into an area.

Nitrification: The biological process in which nitrifying bacteria (primarily nitrosomonas and nitrobacter) utilize ammonia and nitrite sequentially to form nitrate.

Nitrite-oxidizing bacteria (NOB): Bacteria that convert nitrite to nitrate.

Lithotroph: An organism that obtains its energy from inorganic compounds (such as ammonia) via electron transfer.

Standard deviation: A measure that is used to quantify the amount of variation or dispersion of a set of data values. it is the square root of the Variance. The average of the squared differences from the Mean.

Temporary conversion to free chlorine: Also known as a 'burn'—a procedure where a distribution system that usually is disinfected with monochloramine changes the disinfectant to free chlorine in order to 'starve' nitrifying organisms.

Acronyms and abbreviations

This is not an exhaustive list of acronyms and abbreviations, but includes a variety that are used in the context of chloramination and nitrification.

AOB Ammonia oxidizing bacteria (a nitrifier)

CFT Calculated flush time

DAM Directed Assistance Module

DI Deionized

FAA Free available ammonia

FAC Free available chlorine

Mono Monochloramine

NAP Nitrification action plan or a short period of sleep

NOB Nitrite oxidizing bacteria (a nitrifier)

SOP Standard operating procedure

TAC Total available chlorine OR Texas Administrative Code

TLA Three-letter acronym

TMI Too much information

UDF Unidirectional flushing

DAM 8
Creating a Nitrification Action Plan (NAP)

***Disclaimer**: This training describes the regulatory requirements of Title 30, Texas Administrative Code (30 TAC) Chapter 290, relating to public water systems (PWSs). Should there be any inadvertent discrepancy between this training and the rules of 30 TAC Chapter 290, the rules shall apply.*

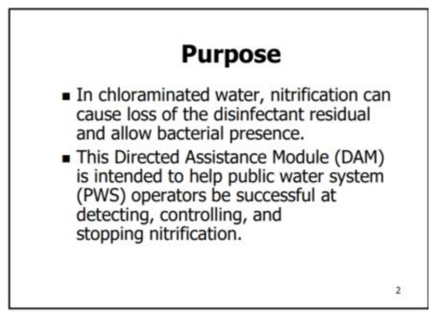
Introduction

The TCEQ Water Supply Division (WSD) trains instructors in how to accomplish this training. If you have any questions regarding the contents of the training itself, contact the TCEQ WSD at 512-239-4691.

The TCEQ created this DAM to be delivered by the TCEQ's Financial, Managerial, and Technical (FMT) service providers. Contact the TCEQ Water Supply Division at 512-239-4691 for assistance.

Purpose

Nitrification is a biological process that can cause a loss of the beneficial disinfectant residual at PWSs using chloramines. A NAP can help control and prevent nitrification. A system that has had a nitrification event does not want it to happen again.



The purpose of this DAM is to help systems that use chloramines prevent and control nitrification.

What is a NAP?

A NAP is a plan for detecting and correcting nitrification, which can destroy total chlorine residuals. During this training, participants will complete portions of the NAP, and make plans to complete it.

A NAP includes:

1. Map of compliance and process management sites,
2. Schedule for sampling,
3. List of Analytical Methods,
4. Goals/baselines and triggers,
5. Actions, and action plans or SOPs.

The first three items were discussed and developed in "**DAM 5: Process Management for Public Water Systems (PWSs) Using Chloramines**". The last two items were discussed in the previous chapters. In this chapter, we will put this together in a NAP table.

Pertinent regulations

Starting July 30, 2015, every public water system (PWS) with chloramines must have a Nitrification Action Plan (NAP) [30 TAC §290.46(z)]. The sampling required for a NAP is described in 30 TAC §290.110.

A NAP is a part of the PWS's Monitoring Plan required under 30 TAC §290.121. The monitoring portion of the NAP may be combined with the distribution system disinfectant residual portion, in which case that should be noted in the text. For example: "This disinfectant residual sampling table includes sampling required for a NAP."

Note: *All of the regulations related to NAPs are included in the materials provided with "DAM 5: Process Management for PWSs Using Chloramines."*

Primary resource: TCEQ Web Site

The TCEQ provides numerous helpful files on their web site at:

www.tceq.texas.gov/drinkingwater/disinfection/nitrification.html

It is highly recommended that the student add a bookmark to that website during the DAM.

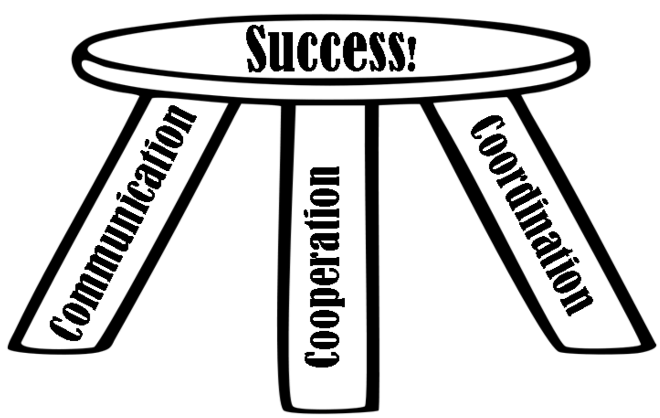
Keys to success

Develop and use your NAP. Review, refine, and upgrade your procedures based on information you gather. Look at the data and see what it is telling you.

Communication is key—between the system and its customers, and also internally. When everyone knows their job and does it, things go smoothly. When customers know what is happening, they are less likely to complain.

Everything goes more smoothly with the "3 Cs:"

- Communication,
- Coordination, and
- Cooperation.



Getting started: Training logistics and 'plant tour'

In drinking water treatment, chloramines are an important tool used to disinfect raw water to inactivate pathogens. When nitrification occurs, it can destroy the beneficial total chlorine / monochloramine residuals.

This Directed Assistance Module (DAM) is intended to help public water system (PWS) operators be successful at detecting, controlling, and responding to nitrification in chloraminating systems. We will cover:

- Nitrification 101—The biology of nitrification;
- Why chloraminating systems have ammonia present,
- How to tell whether nitrification is causing loss of residual —or is it something else?;
- Analyzing the system's data to figure out goals/baselines (normal levels) and triggers showing that the water is off-spec;
- Actions to take when the water is good, bad, or ugly;
- How to combine all this information in one table (matrix) and gather the documents that make up the NAP, and
- How to communicate, coordinate and cooperate to implement the NAP.

This training includes slides and desktop exercises. The classroom portion of the training should be held in a room or office that is clean, dry, and not too noisy. It is helpful to have a blackboard or whiteboard, and a place to project slides.

The two main hands-on activities are analyzing data to set goals/baselines and triggers, and working with the system's map during the flushing discussion. Additionally, if time permits, we may do a plant tour (if there is a plant).

Prerequisites for this DAM

This DAM is intended for people who have some familiarity with chloramines and data for total chlorine, monochloramine, and ammonia. W

If you are not comfortable with basic chloramine chemistry, schedule "**DAM 5: PROCESS MANAGEMENT FOR PWSS USING CHLORAMINES**" prior to scheduling this NAP DAM. Contact the TCEQ at 512-239-4691 to request the Chloramine DAM.

If this DAM is scheduled before a PWS has at least some historical data for monochloramine, ammonia, nitrite, and nitrate, a follow up visit to help set goals/baselines and triggers may be useful.

Data the system needs to bring to the DAM

Before you start this DAM, you should have gathered as much of the following information as possible:

- Monitoring Plan,
- Distribution map,
- Historical data,
- Organizational chart (for a larger system),
- Standard operating procedures (SOPs), and
- A draft NAP—if you have one.

Let the instructor know what information you do or don't have.

CEUs

Instructors for this workshop who are subject-matter-experts (SMEs) approved through the TCEQ's Occupational Licensing process described in Regulatory Guidance (RG) 373 may provide continuing educational units (CEUs) for this training. In order to receive CEUs, attendees must provide a list of the names of staff to be trained, with their license numbers.

For any questions about the instructor approval process, contact the trainer at their number or the TCEQ Occupational Licensing Section at 512-239-1000.

DAM schedule *

Today's training has an ambitious schedule. Please work with the instructor to stay on time. This DAM includes five hours of training; one hour testing and evaluation; and one-and-one-half hours of breaks and lunch. Students will need to commit a full work day to participate in this DAM.

Latitude

The instructor can use their latitude to emphasize points of greatest importance to the PWS where the training is held. However, the overall length of time should not be shortened.

System review/plant tour

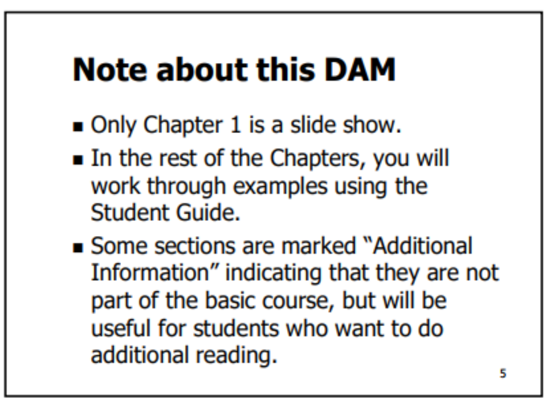
A system with a surface water treatment plant (SWTP) may need to arrange to spend more time on the plant tour and in-plant sampling. A system without a SWTP may want to spend more time on distribution sites and schedules or communication with source water providers.

Basic schedule

Let's review the basic schedule and then talk about what areas need more or less time.

Agenda for DAM 8: NAP Creation

Time	Activity
8:30-8:45	Introduction, sign-in—15 minutes
8:45-9:00	**Pre-Test**—15 minutes
9:00-9:30	**Getting started**—Review today's schedule. **System Summary Table**—Plant tour or desk-top review
9:30-10:30-	**Chapter 1—Nitrification 101** (1 hour)
10:30-10:45	*Break (15 minutes)*
10:45-11:15	**Chapter 2—Part 1--Analyzing data with graphing and mapping** (30 minutes)
11:15-12:00	**Chapter 2—Part 2. Setting Goals/Baselines** (45 minutes)
12:00-1:00	*Lunch (1 hour)*
1:00-1:30	**Chapter 2—Part 3. Setting Triggers** (30 minutes)
1:30-2:30	**Chapter 3—Actions!** (45 hour) Part 1. Routine actions, Part 2. Actions to respond to yellow trigger flags, and Part 3. Actions for red flags—temporary conversion and long-term solution discussion
2:30-2:45	*Break (15 minutes)*
2:45-3:15	**Chapter 4—Communication Strategies** (30 minutes)
3:15-3:45	**Chapter 5—Completing the NAP matrix** (45 minutes) And reviewing the PWS's NAP
3:45-4:00	**Wrapping it up: Post-Test** and review of answers (15 minutes)
4:00-4:30	Submit evaluations. Review Plan of Action



Training materials

The instructor of this DAM will provide copies of the most current versions of this Student Guide. If this training is performed at a PWS, the system will also have to gather some supporting documentation, described above.

Student Guide—Use it today and in the future

This DAM is intended to use the data for the PWS that it is being given at. Please try to have a way to share the distribution map with all the students. For example, make several copies.

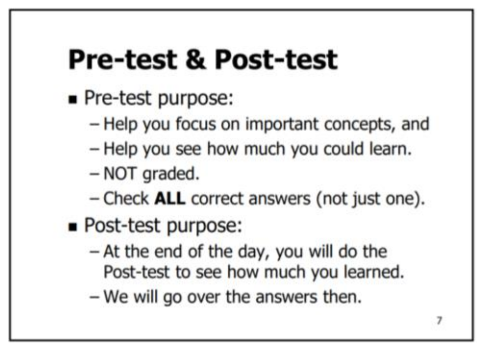
In order for your Student Guide to be useful as a reference, you need to become familiar with it. As you go through the workshops:

- Open the Student Guide to see what information is provided. Tab areas you need to study more.
- Start writing down things you need to follow up on.

Additional information

Some of the contents of the Student Guide are not used in the on-site portion of the DAM, because you will learn them from doing examples. An expanded version of some concepts is included so you can read it later.

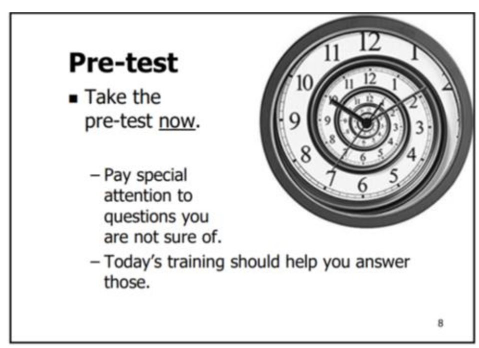
Pre- and Post-Test



This DAM includes a Pre- and Post-Test intended to help the student's learning process. These tests will NOT be graded.

Check ALL correct answers—there may be MORE THAN ONE correct answer.

When you take the Pre-Test, note the questions that were puzzling—the answers will be covered in the course. If they are not—make sure to ask about them. At the end of the day, we will go through the answers on the Post-test.



Training Evaluation Form

A Training Evaluation Form is included in this Student Guide. Students will complete this evaluation and return it to the instructor who will collect those to route securely to the TCEQ's Water Supply Division, who developed this training. By submitting your input, the TCEQ can continue to improve the training we develop.

Plan of Action

This DAM should result in actions by the participants to develop or improve the chloramine management at this PWS. During the day, note your ideas about what to do on the Plan of Action provided in Appendix 4.

Notes

System Summary Table: Getting to know this system

Before getting into the details of the training, it is important for the instructor and participants to focus on the PWS that needs assistance, so that the most important topics can be emphasized.

Note: *If the PWS participated in "DAM 5: Process Management for PWSs Using Chloramines" recently, you may be able to just refer to the summary table developed during that event.*

System name/PWS ID:
Population
Comments:
Source(s)—Does the plant use wells, surface water, or purchase?
Treatment—Does the plant treat water? Where? With what chemicals?
Entry Points—Does water from sources or plants blend before entering distribution?
Distribution system: What type(s) of disinfectant(s) are in distribution? Where?

Note: Use additional paper if needed.

System Summary

System name/PWS ID:
Additional notes:

Chapter 1. Nitrification

*This DAM does not cover chloramination chemistry. It is important to be familiar with breakpoint chloramination before participating in this DAM. If you need to learn more about chloramination, call the TCEQ's Financial, Managerial, and Technical Assistance program at 512-239-3105 and ask for "**DAM5: PROCESS MANAGEMENT FOR PWSS USING CHLORAMINES.**"*

During this chapter, we will describe the biological process of nitrification and why it is so important to chloraminating systems. We won't get into the biology too deeply—just deeply enough that we can use our knowledge to find and fix problems caused by it, and hopefully stop it before it starts.

NOTE: The slides for the presentation are inserted throughout the guide so that students can keep their notes and manuals in the same place.

Scope

The scope of this Chapter is the underlying biology, and a little review of chloramine chemistry, that we will use to build our Nitrification Action Plan (NAP) during the following Chapters. We will try and answer the questions:

- What is nitrification?
- Why is there ammonia present? and
- Why do I care?

Learning goals

Part 1.

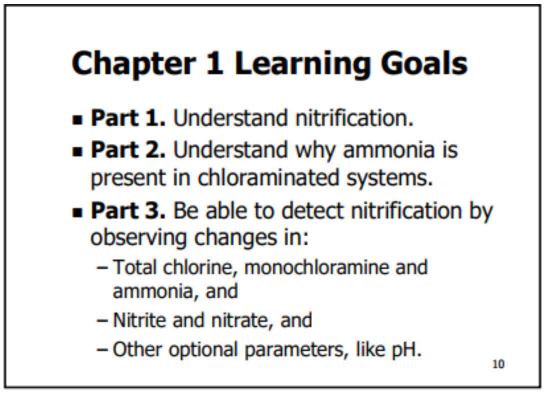
- Be able to describe the nitrification process.
- Be able to explain the two types of nitrifying bacteria and what they do.

Part 2.

- Understand why ammonia is present in chloraminated water.
- Be able to describe the chemicals present, and their degradation.

Part 3.

- Know what effect nitrification has on levels of total chlorine, monochloramine, and free ammonia
- Know how nitrite and nitrate levels change during nitrification
- Be able to determine whether reduced total chlorine and/or monochloramine levels are caused by nitrification or something else.



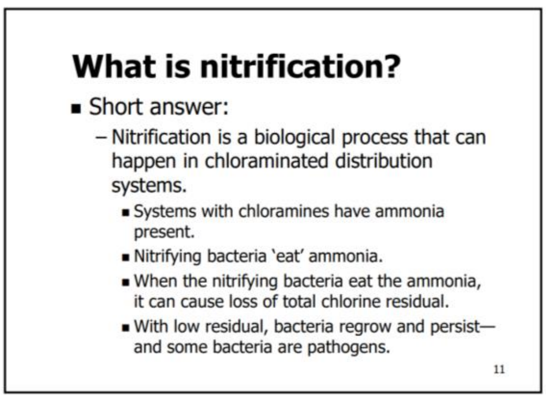
Materials

During this first Chapter, the main materials used are the

- Student Guide, and
- Slides.

Part 1. Nitrification 101

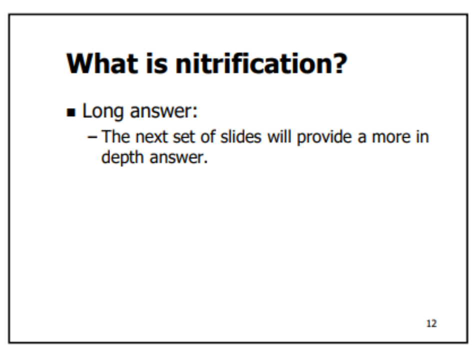
Nitrification happens when bacteria that can 'eat' ammonia are present in pipe biofilms, and there is enough ammonia for them to eat. These bacteria are called 'nitrifiers'.



The short answer is that nitrification can cause loss of disinfectant residuals, and when that happens, bacteria can grow and persist. Bacteria should not be present in drinking water because some of them are pathogenic—so that is a bad thing.

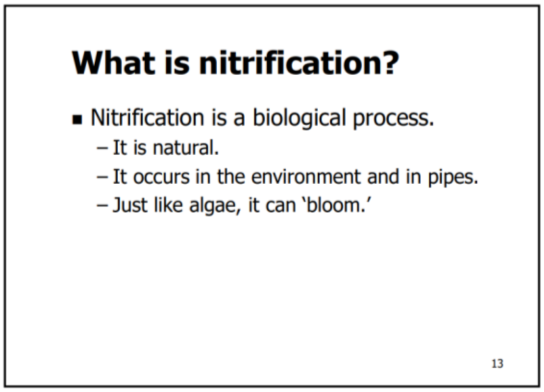
We will go into more depth because when you know more, it will give you better ability to troubleshoot and correct problems in distribution.

The long answer will take a few more slides.



Nitrification is not limited to chloraminated distribution systems. It is a natural process that occurs in the environment—when and if conditions are right for that particular type of bacteria to grow.

When it happens—it will happen more in some places than others. In places where there is more 'food' there will be more nitrification. In that way, it 'blooms' just like algae can 'bloom' in a lake. This means you could have nitrification in one part of your system but not in another area.

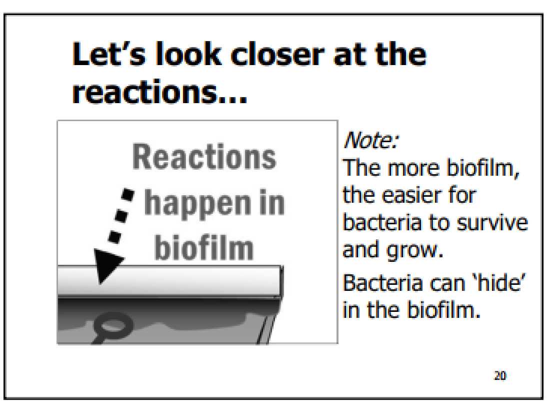


First, let's focus more closely on exactly what is happening at the microscopic level.

Most reactions take place in static biofilm rather than the flowing bulk water. This brings up one important point—Where there is more biofilm, there is more potential for nitrification. The bacteria have a safer, more protected environment.

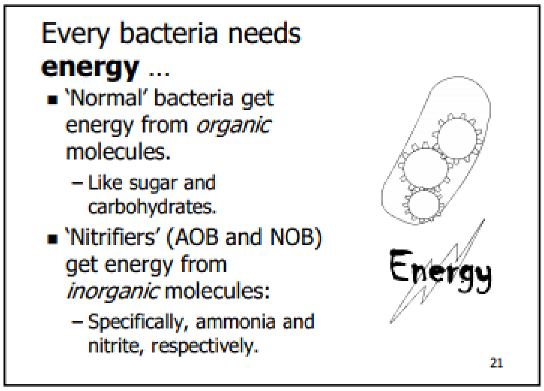
Even new PVC pipe has a biofilm—even if you can't see it on a cut pipe, because it is microscopic.

The biofilm on iron pipes is often thicker than the one on plastic pipe—but even if you can't see it, it is still there, just very thin. Biofilm thickness is variable but is usually in the range of 50 to 100 microns, half the diameter of a human hair.



Every bacterium needs energy and building blocks. The way that bacteria get those is how they are classified and named. Together, we call the energy and building blocks "food."

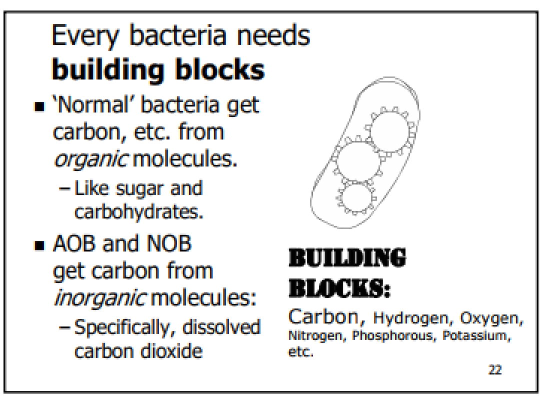
Most bacteria 'eat' sugar and other organic molecules to get the energy they need. However, nitrifying bacteria get their energy from the inorganic molecule ammonia.



Also, bacteria need 'building block' chemicals to build more bacteria. The 'building blocks' that make up bacteria are those that make up all life, like:

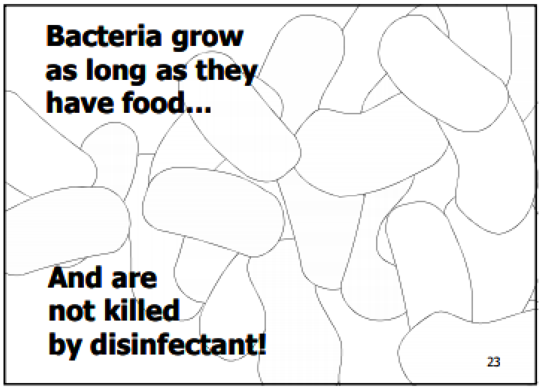
- Carbon,
- Hydrogen,
- Oxygen,
- Nitrogen,
- Phosphorous,
- Etc.

The normal bacteria—like the ones growing on that old piece of blueberry pie in the fridge—get their carbon (etc.) to make more bacteria from sugar and carbohydrates, which are the same as their food source.



As long as bacteria have food to provide building blocks and energy—they will keep growing, making more and more copies of themselves, till the food is all gone. However, in the presence of a disinfectant, some or almost all bacteria can be killed or 'sterilized' (caused to be unable to reproduce).

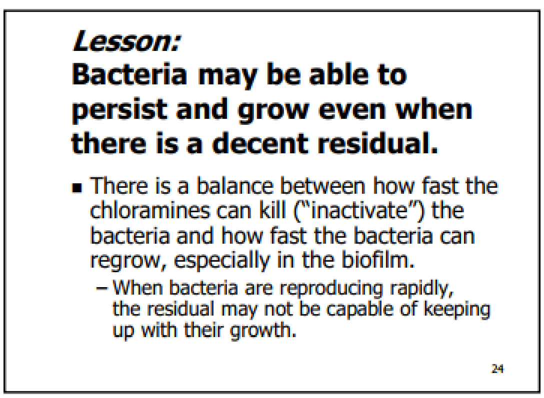
The next slide illustrates this.



Nitrifiers are the same—as long as there is ammonia for them to eat, they will keep growing, unless there is enough disinfectant to kill (inactivate them) or unless they run out of food and starve.

There is a balance between how fast the chloramines can kill ("inactivate") the bacteria and how fast the bacteria can regrow. Nitrification happens when that balance shifts to where the bacteria are eating ammonia and growing too fast for the chloramines to kill all of them.

We like to think that as long as there is a 'decent' disinfectant residual, bacteria can't grow. But if they are hidden in the biofilm where they are protected against the disinfectant, and as long as there is plenty of food, they can overcome the adversity of having the residual near them and survive to grow more bacteria.

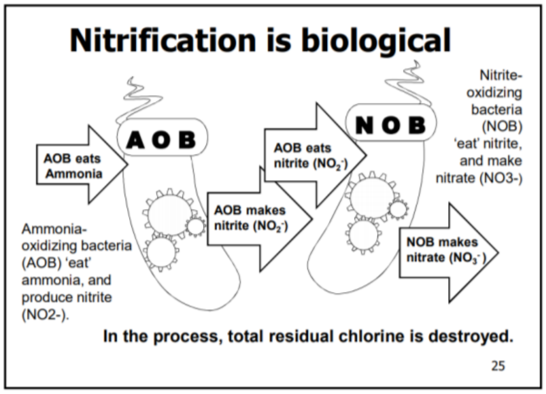


So let's get even deeper into this biological process.

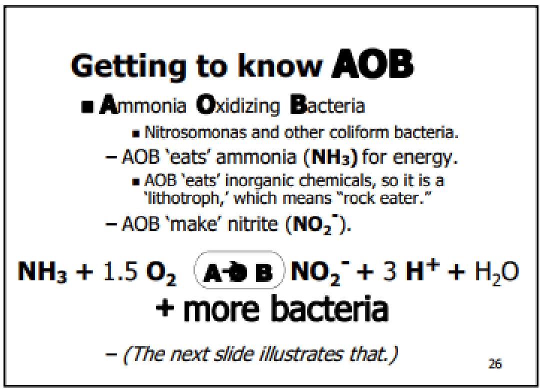
Looked at these biological reactions in series, you can see that the ammonia-oxidizing bacteria (AOB) eat ammonia and produce nitrite. Ammonia is their food and nitrite is their waste product.

The AOB are a boon to the nitrite-oxidizing bacteria (NOB), because they produce nitrite which is food for them. For the NOB, nitrite is their food, and nitrate is their waste product.

An overview of the entire process shows how the two sequential biological reactions are connected.

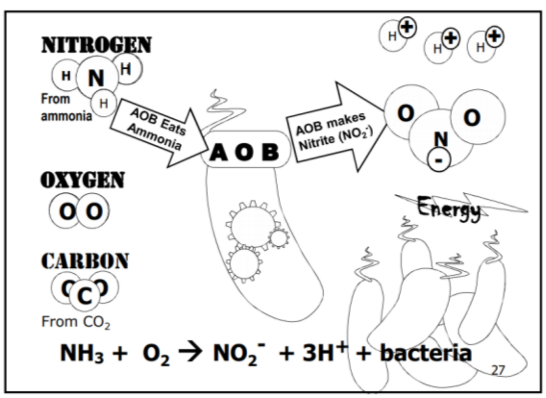


First, let's get to know the ammonia-oxidizing bacteria (AOB). The next slide shows the growth process for AOB.



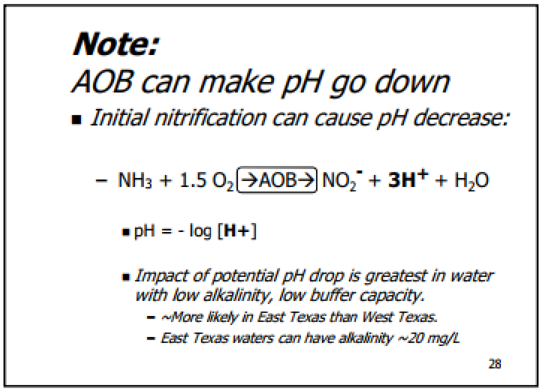
Instead of getting their 'building blocks' from leftover people food, AOB use the carbon dioxide and other chemicals in water.

The next slide illustrates that:



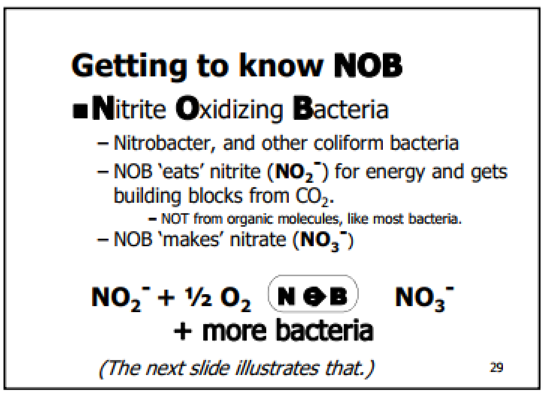
This is a harsh environment with less available 'food' compared with bacteria that grow on sugar and carbohydrates. Therefore, AOB grow slowly compared to the bacteria we are most familiar with, like those in aerobic, activated-sludge wastewater treatment plants, or in a glass of milk left at room temperature.

When AOB eat ammonia, they make nitrite, and they also make some protons. As we talked about in the chloramine DAM, protons (or hydrogen ions) are what makes water acidic. So, having AOB in water can potentially drop the pH.

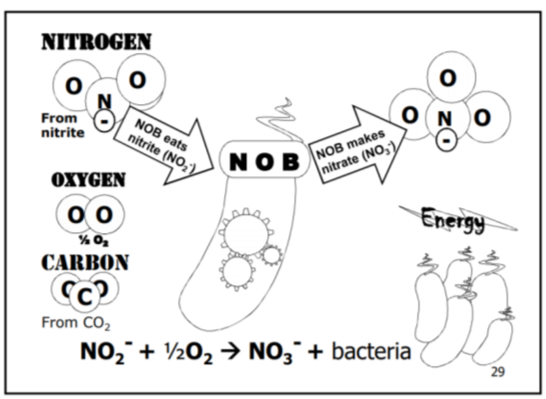


Next, after the AOB have made enough nitrite, the NOB have food to grow on.

NOB, just like AOB, get their building blocks from chemicals that are in the water. And, they grow even slower than the AOB. the biofilm becomes a place where NOB can love to grow.

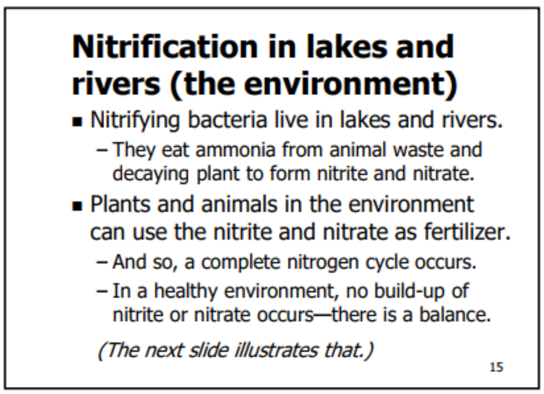


The following slide illustrates the same information in graphical form.



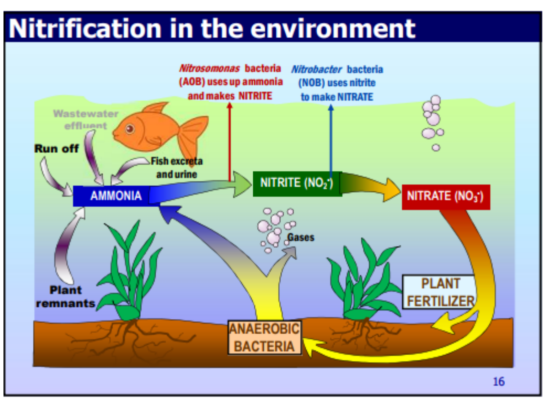
Since nitrification is natural and occurs in the environment, let's talk about what that looks like. It can shed light on what happens in our distribution system.

In natural water bodies, nitrification has a cycle of life. Plants decay and animals produce waste that contain ammonia… then nitrifying organisms eat the ammonia and produce nitrite and nitrate… then plants and animals use the nitrite and nitrate as fertilizer for growth.



For plants and animals in natural water, nitrogen may be their limiting growth factor. When the natural cycle is balanced, there is no unhealthy buildup of any nitrogen-containing chemicals.

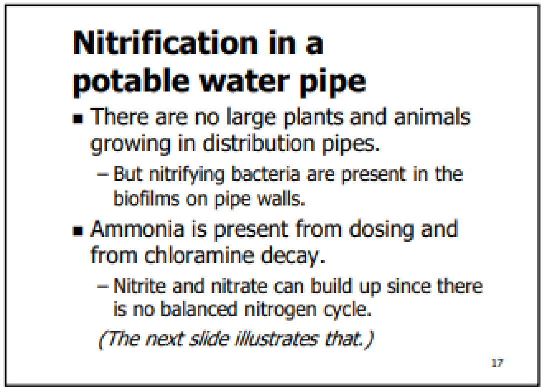
The two organisms responsible for most conversion of ammonia to nitrite and nitrate are nitrosomonas and nitrobactor, respectively.



Things are different in a distribution water pipe. The first difference is that there are no plants or animals larger than a microbe—or there better not be! However, there is a biosystem, concentrated primarily in the biofilm that is present on every pipe surface.

Bacteria stick to surfaces in order to survive. In water environments, the nutrients that bacteria need tend to accumulate at surfaces, so bacteria have 'adhesins' that help them adhere to surfaces—and each other. Bacteria that can stick to surfaces have an advantage over ones that are free-floating (sometimes called 'planktonic').

This is why mountain creeks may contain crystal clear water, while stepping stones underneath the water may be covered with a slippery film of adhering microbes.

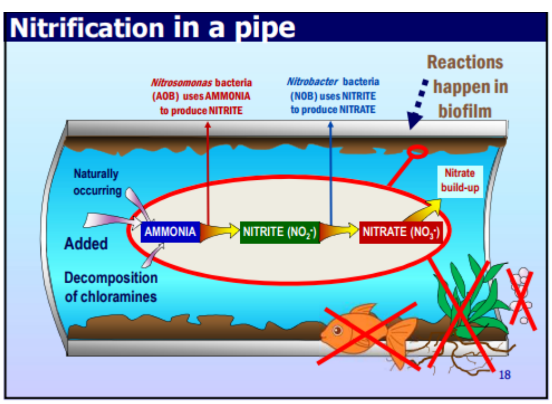


Unlike in the natural environment, macroscopic animals and plants are not present. Algae is not present because it needs sunlight.

In a pipe, ammonia is not present from animal waste (should not be!) but may be naturally occurring in source water, may be added in excess when dosing to form chloramines, and also is generated as monochloramine decays.

The same reaction that happen in the natural environment can happen in a distribution pipe. The microorganisms are the same ones as in lakes and rivers.

Therefore, nitrifying organisms have a place to grow. But, there is no 'natural cycle' in a distribution pipe.



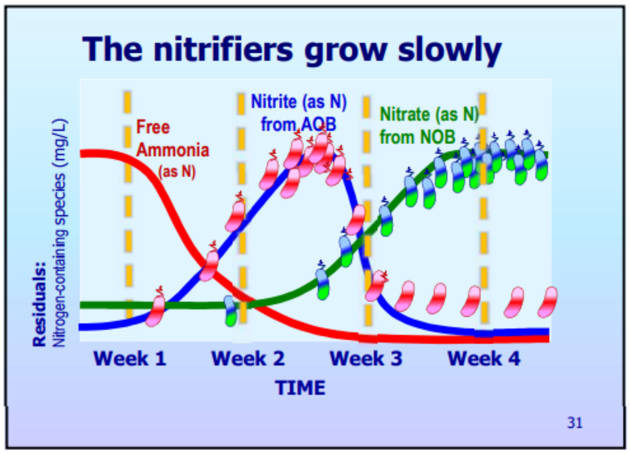
To sum up: the same reactions that occur in a natural environment can occur in a distribution pipe, with the same microorganisms (for example, nitrosomonas and nitrobacter).

Speed of reactions

This process is not extremely rapid. In fact, nitrifying organisms are slow growers. They grow much more slowly, for instance, than the bacteria that eat organic food like sugar and carbohydrates. That is one major point of explaining how their food is less available than the organic-eaters.

It takes a couple of weeks for the AOB to really get started eating ammonia to the point where we can detect it, and even longer for the NOB to respond to the presence of nitrite formed by those AOB.

The next slide illustrates that timing.



In this slide, the situation being described is as follows:

- At first, ammonia is present, and a 'seed' AOB organism is present.
- By week 1, the AOB is starting to grow, causing a decrease in ammonia and an increase in nitrite.
- By week 2, the AOB is growing fast enough that it can eat most of the ammonia, causing the residual ammonia to drop even farther.
- Also in about week 2, the NOB is noticing the increase in available nitrite. Therefore, NOB is starting to grow.
- As the NOB population increases, it is able to eat all of the nitrite that the AOB can produce.
- By week 4, nitrification is entrenched. As soon as new ammonia is available, the stable population of AOB eats it, forming nitrite. As soon as that nitrite is available, the stable population of NOB eats it, forming nitrate.

Note that in week 4 it looks like the ammonia is all gone. This would be true if you had a beaker of water on a shelf in the lab. However, in the distribution system, new ammonia is provided continuously, from the fresh water entering the area.

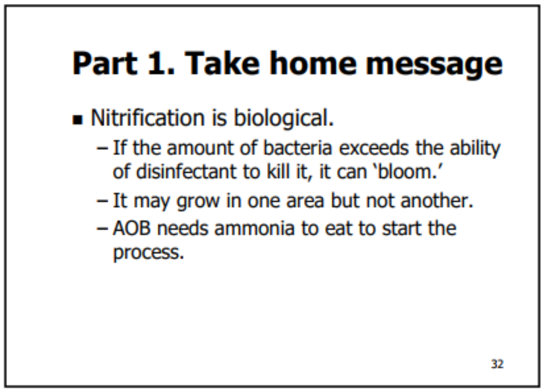
Since we don't directly measure the actual bacteria, we can't use bacterial presence as an indicator of nitrification.

In a distribution system, we tend to talk about water age in days, not weeks. But it is not that unusual for distant areas, or cut-off areas, to have long enough water age to allow these nitrifiers to take hold and grow.

Part 1: Take-home message

The take home message from this part of the DAM is:

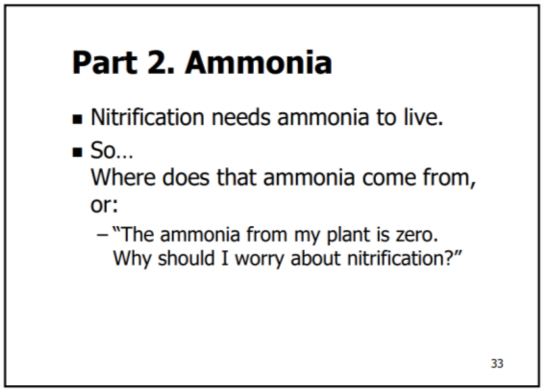
- Nitrification is a natural biological process that is fairly well known.
- If organisms are growing quickly enough, they can have an impact on water quality even in the presence of a disinfectant.
- Nitrification can occur in one part of the system, while other areas are completely free of it.
- In order to get the nitrification process started, ammonia must be present for a ‘seed’ organism.



In this discussion, we started the process by assuming the presence of ammonia. Next, we will take a closer look at why ammonia is ever-present in chloraminated distribution systems.

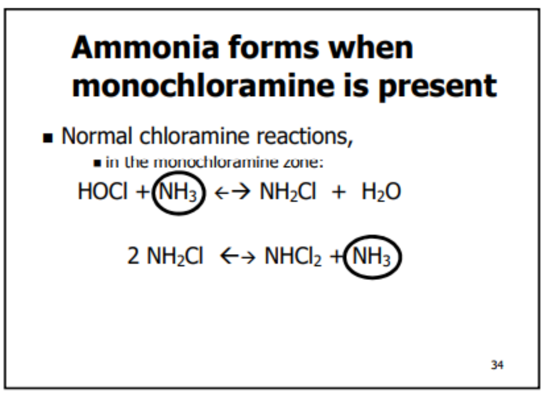
Part 2. Ammonia

If there were no ammonia present, nitrifiers could not grow. A treatment plant may do a fantastic job of chloramination—successfully producing water at the optimum chlorine-to-ammonia-nitrogen (Cl_2:NH_3-N) ratio, with absolutely no free available ammonia in the produced water. Even then, the distribution system has to worry about nitrification.

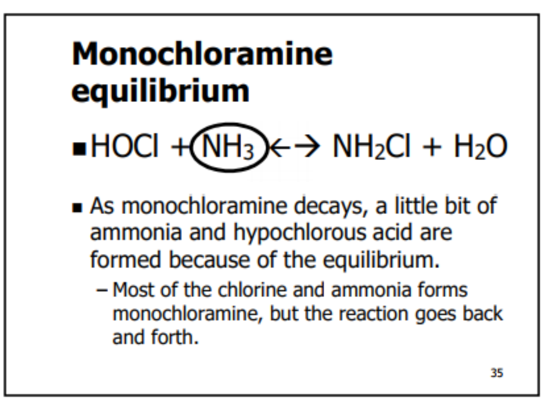


Chloramines naturally release ammonia as they degrade. That would not be a problem—ammonia is not toxic at those low levels—except that having ammonia present provides food for the nitrifiers.

There are two reactions that re-form ammonia from monochloramine.

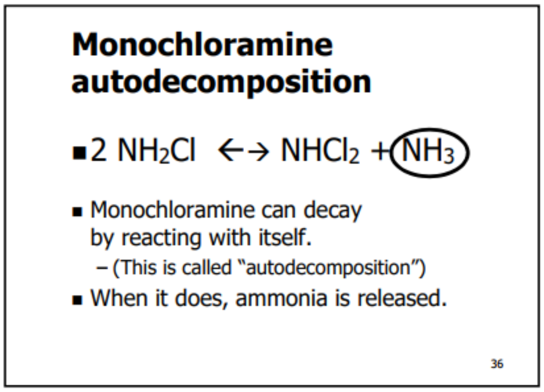


The details of these two reactions are described in the next two slides. The first reaction is the monochloramine equilibrium itself.

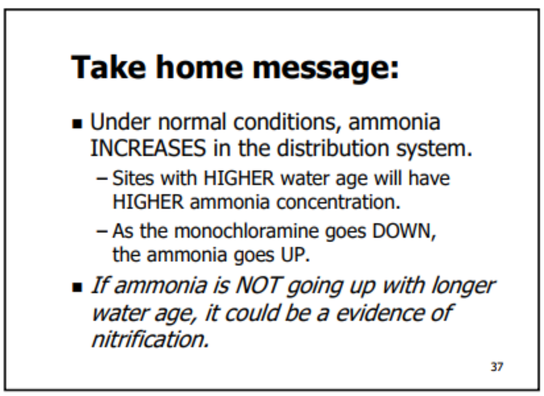


There is always a little 'back and forth' between the monochloramine and the chemicals it is formed from—chlorine and ammonia. As the monochloramine decays, perhaps by killing a pathogen, it drives this equilibrium to the left, forming a little bit of ammonia.

The second reaction is autodecomposition of ammonia. As we discussed in "**DAM 5: PROCESS MANAGEMENT FOR PWSS USING CHLORAMINES**," monochloramine can attack and react with itself. When it does this, the reaction forms ammonia.



These two reactions combine to form enough ammonia that if there is a seed-organism present to eat it—they will find it and eat it.



The take home message from this part of the chapter is:

- ***Ammonia naturally increases with time*** in chloraminated distribution system, under normal conditions.
- ***If ammonia is not increasing, it might be due to nitrification.***

This is counterintuitive for water operators. We are so used to talking about disinfectants which decay and go DOWN with longer water age that it is kind of hard to talk about a chemical that goes UP with longer water age. But that is what it does!

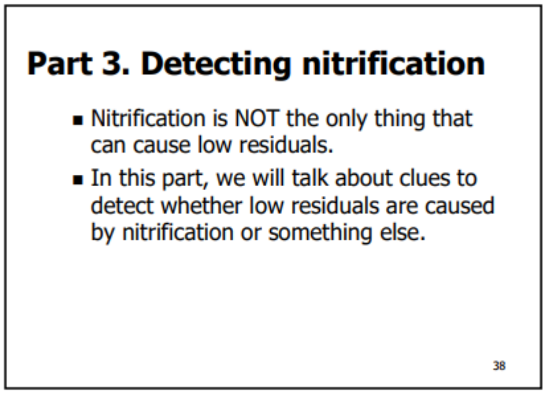
This knowledge will help us understand how to interpret water quality results in the distribution system.

Part 3: Take-home message:

In Part 2 of this chapter, we will combine what we have learned so far to talk about how we can tell whether nitrification is happening—or whether some other phenomena is causing low residuals.

Part 3. Detecting nitrification

In order to fix something, we have to find it. The way we find nitrification is by looking closely at the total chlorine, monochloramine, free ammonia, nitrite, and nitrate data. If we look closely enough, the data will start to talk to us and reveal its secrets.

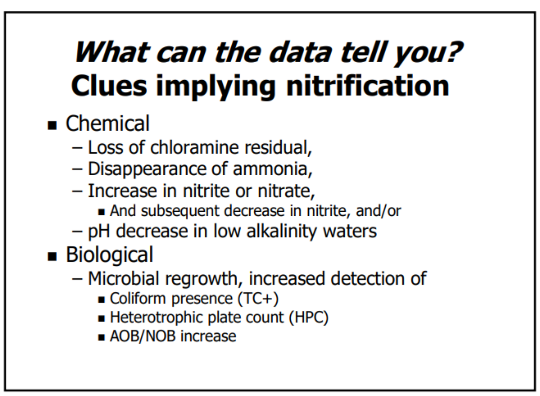


From our discussion so far, we know that some data will change when nitrification occurs:

- Total chlorine and monochloramine will decrease,
- Ammonia will decrease,
- Nitrite will increase in the earlier stages, and decrease in the later stages of nitrification,
- Nitrate will increase.

Also

- pH may decrease, but only in low alkalinity waters,
- Bacterial indicators can increase—nitrification is a major reason for total coliform positive results in chloraminated systems.

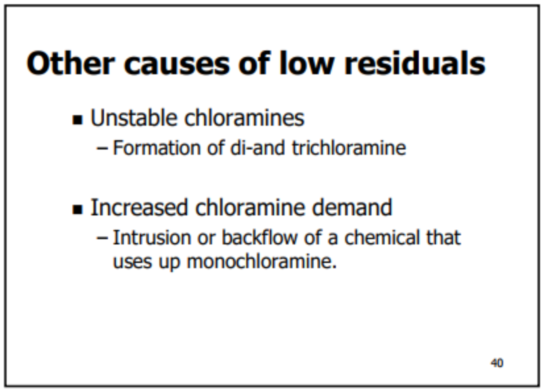


While these clues can help us detect nitrification, we have to consider them as a group in order to get the full picture. Next, let's talk about whether the clues are pointing to nitrification or to something else entirely.

Is it nitrification? Or something else?

Nitrification is not the only thing that can cause low residuals. If we want to take the correct actions, we had better know whether it is nitrification or something else It is important to eliminate all possibilities before taking action to fix nitrification. The two most common things that people mistakenly think are nitrification are:

- Unstable chloramines, and
- Increased demand.



As summarized in Figure 1, the data must be analyzed to determine whether low residuals are caused by unstable chloramines, increased demand, or nitrification.

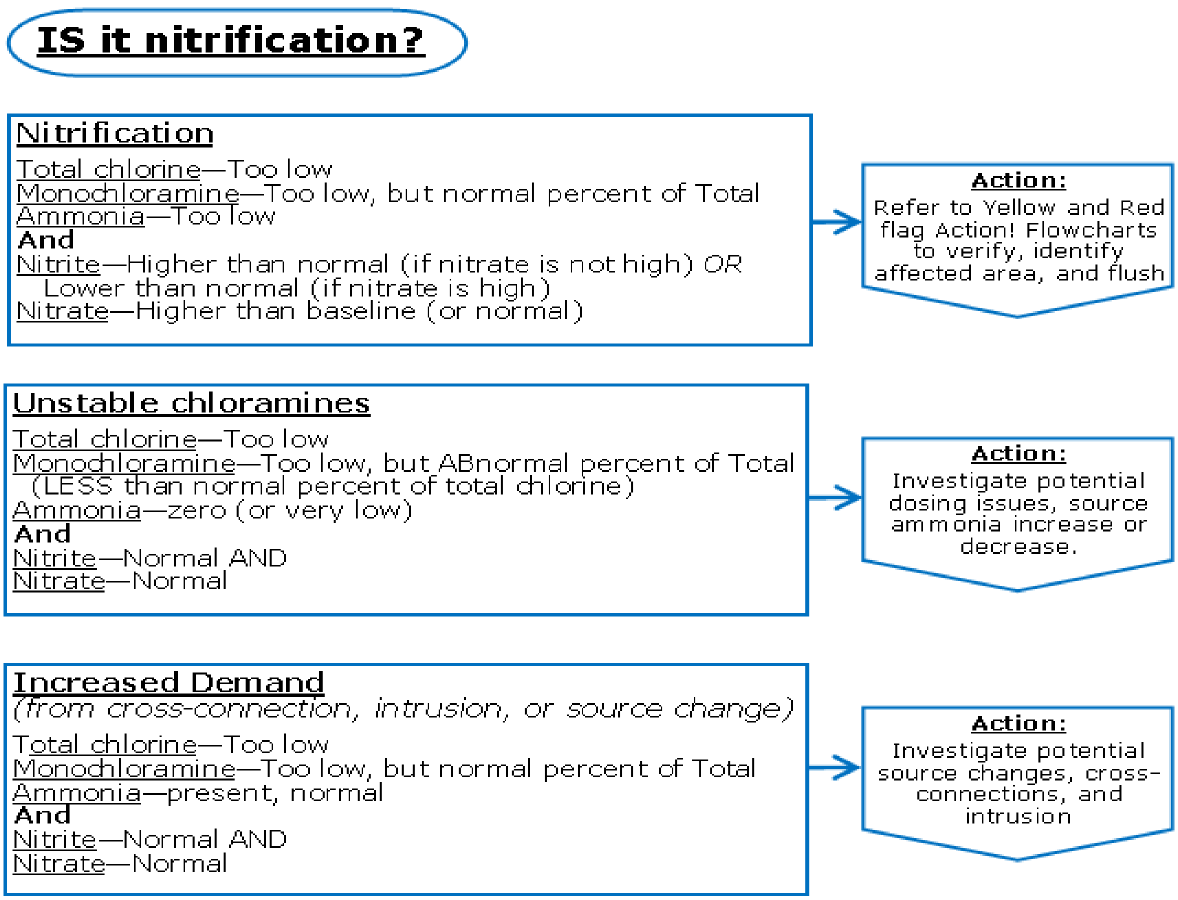
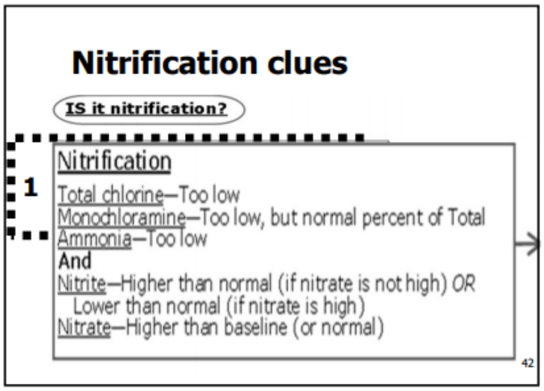


Figure 1. Illustration of nitrification and other common causes of low residual

These three conditions are described in detail in the next three slides.

1. Nitrification

After learning about how the biological process of nitrification works, we can identify some clues that can tell us that nitrification is occurring.



First, we learned that when nitrification occurs, the total chlorine and monochloramine residuals decrease. This is often our first clue that some problem is happening, so it is similar to the other two conditions we talk about next.

When nitrification occurs, we will usually see that the comparison between total chlorine and monochloramine is not too different than it is during normal conditions. For example, if the monochloramine is always about 90% of the total chlorine, we may not see that change when nitrification is happening. This will be the case in the earlier stages of nitrification, when we still have a chance to catch it.

However, nitrification that is really bad can cause unstable chloramine residuals when all of the ammonia is destroyed—usually this will happen when the total chlorine and monochloramine levels have dropped so low that it is hard to detect a significant difference between them.

During nitrification, ammonia will drop. That is a certainty, because the AOB are eating ammonia to form nitrite.

Nitrite may go up or down. At the earlier stages of nitrification, nitrite will go up because AOB are eating ammonia and forming nitrite. Later, as the NOB start growing, nitrite will go down because NOB are eating the nitrite and forming nitrate.

Nitrate will go up after nitrification gets bad. High nitrate can only occur because of nitrification or cross connection with a wastewater source that contains nitrate.

2. Unstable chloramines

As we discussed in "**DAM 5: PROCESS MANAGEMENT FOR PWSS USING CHLORAMINES**," when chloramines get unstable, and the chlorine-to-ammonia-nitrogen (Cl2:NH3-N) ratio drifts towards the breakpoint, the total chlorine residual level decreases.

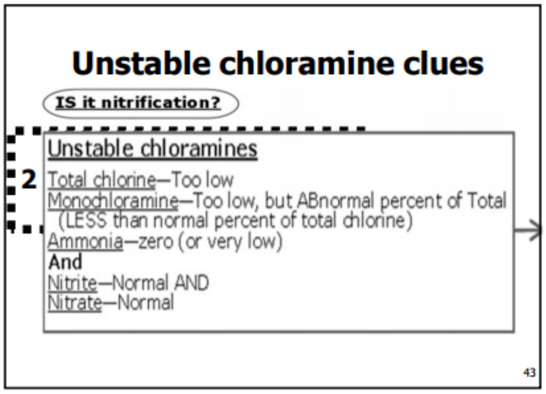


Figure 2 shows a simplified breakpoint curve. The unstable zone is Zone 3 in the figure.

When chloramines become unstable, the total chlorine and monochloramine both drop. At the same time, they are getting farther apart—monochloramine decreases more quickly than total chlorine because the monochloramine is being converted to dichloramine and trichloramine. Those (di and tri) show up in the total chlorine, but are useless and stinky.

For example, if the normal percent of total chlorine that monochloramine is 90%, if it drops to 80% or 70% that may be a clue that chloramines are unstable.

When chloramines become unstable, the ammonia is gone. It is getting used up by the dichloramine, trichloramine, and other products like nitrogen gas—all of which are useless from the perspective of disinfection.

Finally, unstable chloramines have no impact on nitrite and nitrate. Therefore, if the reason for low total chlorine and monochloramine is unstable chloramines, one way to tell is that the nitrite and nitrate will be at normal levels.

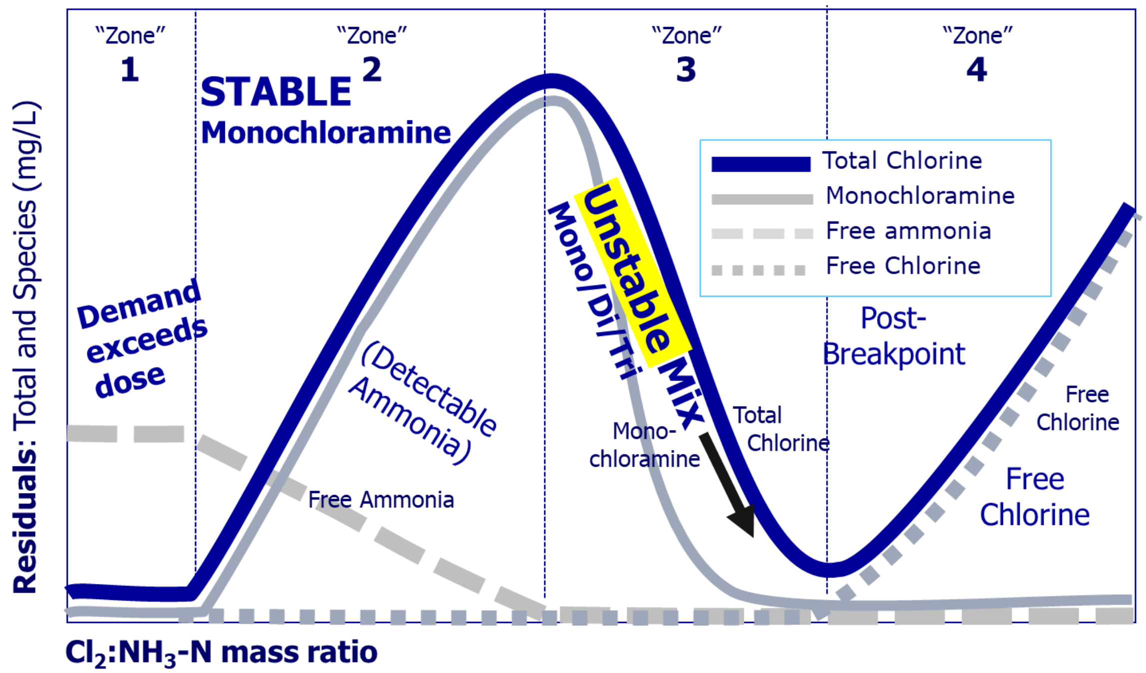
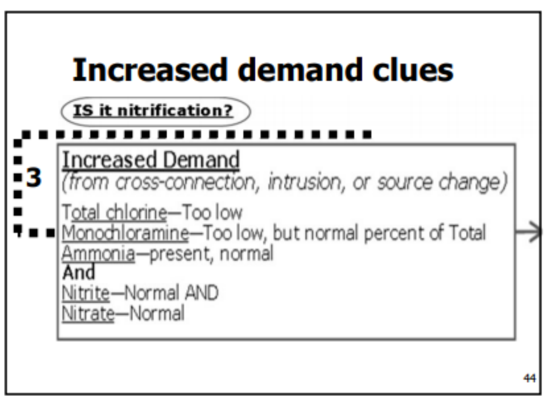


Figure 2. Simplified breakpoint curve

3. Increased demand

Looking back at the breakpoint curve, remember in Zone 1 iron, sulfides, and other material cause 'demand' that uses up total chlorine and monochloramine. One possible reason for lower-than-normal total chlorine and monochloramine is an increase in demand.



Knowing that, we have to ask the follow-up question:

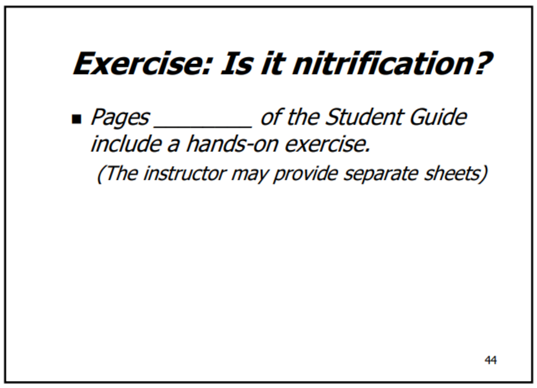
What can cause the demand to increase.

One way is if the source water changes. For example, rain could cause more runoff containing demand-causing chemicals to the extent that the treatment plant can't remove them. In this case, we need to look at the source and plant to figure out what exactly is happening.

Another more insidious way demand can increase is through intrusion or cross connections. The water may be leaving the plant with low demand—but then, in distribution, more demand could be leaking in from the soil around the pipe because of leaks and pressure variation. Or, an actual plumbed cross connection can occur with chemicals that have increased demand. In this case we have to look around for backflow, backsiphonage, or intrusion in distribution.

If the ONLY thing leaching or backflowing into the system is demand chemicals, there will be no impact on the nitrite and nitrate levels. However, we should not forget that nitrate and nitrite could also get into the system through a cross-connection. That is unusual but could happen.

Figure 1 summarizes the conditions that can seem like nitrification. Hopefully, this figure and this discussion make it clear why nitrite and nitrate measurement is necessary to figure out whether low residuals are really the result of nitrification. (Chapter 2 discusses what "too high" or "too low" means, Chapter 3 discusses actions.)



These examples ask us to look at the data provided, and figure out whether or not nitrification is occurring:

Example: Is it nitrification?

Here in the City of Lillville, we purchase and redistribute chloraminated water. The takepoint from the City of Supply is far away from their plant. Sometimes, they send us water with a low total chlorine residual.

The expectation is that water we purchase will have the following quality:

Total chlorine:	**= 2.5**
Monochloramine:	**= 2.4**
Free ammonia:	**= 0.4**
Nitrite:	**= 0.035**
Nitrate:	**= 1.2**

However, the water quality that we receive does not always meet those expectations.

Example 1. April

In April, we analyzed the water as it entered our system and found:

Total chlorine	= 1.5 mg/L
Monochloramine	= 1.4 mg/L
Free ammonia	= 0.1 mg/L
Nitrite	= 0.065 mg/L
Nitrate	= 1.2 mg/L

Is nitrification occurring?

If not, do you think you know why the residual is low?

Example 2. May

We kept sampling, and in May, we found:

Total chlorine	= 0.5 mg/L
Monochloramine	= 0.4 mg/L
Free ammonia	= 0 mg/L
Nitrite	= 0 mg/L
Nitrate	= 1.7 mg/L

Is nitrification occurring?

If not, do you think you know why the residual is low?

Example 3. October

After a long hot summer, and various discussions with the City of Supply, we got good residuals for a while. Then, in October, we found:

Total chlorine	= 2.1 mg/L
Monochloramine	= 1.3 mg/L
Free ammonia	= 0 mg/L
Nitrite	= 0.035 mg/L
Nitrate	= 1.2 mg/L

Is nitrification occurring?

If not, do you think you know why the residual is low?

Example 4. December

Things got better for a while, then, in December, we found:

Total chlorine	= 1.4 mg/L
Monochloramine	= 1.3 mg/L
Free ammonia	= 0.4 mg/L
Nitrite	= 0.035 mg/L
Nitrate	= 1.2 mg/L

Is nitrification occurring?

If not, why was the residual low?

Additional Information:
Summary of critical control parameters for chloramination

For the avid student, the text provides an additional summary of the control parameters for chloramination.

Total chlorine

Total chlorine is the sum of all active chlorine species. It is the regulated level.

The TCEQ minimum allowable total chlorine residual is 0.5 mg/L throughout the distribution.

The EPA and TCEQ maximum residual disinfectant level (MRDL) for total chlorine is 4.0 mg/L *based on the running annual average (RAA) of all samples collected in distribution*. Maintaining a residual over the 4.0 mg/L at entry points is not a violation in and of itself, as long as the average is less than 4.0 mg/L.

The minimum and maximum total chlorine residuals in distribution are reported on the Disinfectant Level Quarterly Operating Report (DLQOR) or the Surface Water Monthly Operating Report (SWMOR).

Entry point samples should NOT be reported on the DLQOR because the entry point is, by definition, NOT a distribution sample site (unless it is at the first customer's tap).

Every total chlorine residual *collected at a compliance site* must be reported on the DLQOR or SWMOR.

Monochloramine

Monochloramine is the disinfecting member of the chloramine family.

Ideally, like in distilled water, all the total chlorine will be present as monochloramine—the concentration will be exactly the same. However, in real water, the monochloramine is often less than the total chlorine. Generally, any water usually has a normal percent of total that is mono—like 90% or something.

Keeping track of the percent of monochloramine in the total chlorine can help alert you changes and to possible nitrification.

Free ammonia

Free ammonia reacts with free chlorine to make monochloramine and other chloramines. Then, as the monochloramine decays, free ammonia is released.

Free ammonia and total ammonia may be present in source water.

Total ammonia includes organic amines that don't provide disinfecting power. They can react with the free chlorine to form other compounds. Even so, they can contribute to the total chlorine measurement—that is why the percent of the total chlorine that is monochloramine is sometimes not 100%.

Nitrite

Nitrite is formed by ammonia-oxidizing bacteria which 'eat' ammonia.

Nitrite may be present in source water.

Note. Nitrite has a health-based maximum contaminant level (MCL) of 1 mg/L at entry points, but is not regulated at distribution system sample sites. However, it is still a public health concern when it is over the MCL.

<u>Nitrate</u>

Nitrate is formed by nitrite-oxidizing bacteria which 'eat' nitrite.

Nitrate is often present in source water, especially groundwater.

Note. Nitrate has a MCL of 10 mg/L at entry points, but is not regulated at distribution system sample sites. However, it is still a public health concern when over the MCL.

<u>Free chlorine</u>

You are **not required to measure free chlorine**, except during a temporary conversion to free chlorine performed as a preventive or corrective action.

<u>pH</u>

A **decrease in pH** can indicate nitrification. Therefore, pH measurement is recommended at systems with low alkalinity.

PWSs that use pH elevation for corrosion or nitrification control should also monitor pH in the distribution system.

Some PWSs are required to measure pH as part of the Lead and Copper Rule requirements for WQP (water quality parameter) testing

<u>HPC</u>

HPC means 'heterotrophic plate count' bacteria.

HPC can be a useful tool to measure the concentration of a broad range of bacteria. An **increase in HPC** may indicate nitrification under some conditions, and in some systems.

Nitrifiers are from a different family of bacteria than HPC, so HPC is not a direct indicator of nitrification. In some conditions, like if there is no residual and there are seed HPC organisms, HPC can grow at the same time as nitrifiers.

PWSs are not required to measure HPC.

<u>Other indicators</u>

Nitrification/denitrification indicators used in wastewater treatment, such as dissolved oxygen, alkalinity, oxidation-reduction potential, may be useful for drinking water in future, but need further research. Generally, the chemistry and biology of wastewater is so different to drinking water it is hard to make sweeping comparisons and have them be accurate.

<u>Why does nitrification cause residual loss?</u>

This question is beyond the scope of today’s training. However, this information is provided for students who wish to gain greater understanding.

In 1995, one of the first in-depth research papers on nitrification stated that degradation of chloramine residuals is caused by chloramine oxidizing nitrite that is produced during nitrification.

With what we have learned since 1995, the following are identified as possible mechanisms for chloramine residual loss during nitrification.

- Monochloramine will oxidize the biologically produced nitrite, as previously stated, but there are now some questions regarding how significant this pathway will be as it is highly pH dependent.
- Monochloramine reacts with the bacteria cells and their soluble by-products that are formed during active nitrification.
- Monochloramine is co-metabolized by ammonia-oxidizing bacteria (AOB). This means, they eat the monochloramine by accident while they are trying to eat what they really want—like when you accidently eat part of your hamburger's paper wrapper.
- Monochloramine can react with hydroxylamine (the intermediate as ammonia is biologically oxidized to nitrite by AOB).
- When the free ammonia is consumed, it will push monochloramine to break back down into free ammonia and free chlorine. Depending on how fast free ammonia is consumed, you may also have the effect of forming more dichloramine as you are also briefly raising the chlorine-to-nitrogen ratio by consuming free ammonia. Faster dichloramine formation will also lead to faster residual loss.

All of the above are competing reactions and might be the important one, depending on the specific water quality conditions with pH and temperature likely being the most important parameters. Kinetics will dictate the victor.

Nitrogen balance (optional)

Enthusiastic students may be interested in learning about the nitrogen balance, so additional information is provided in this text.

If you are comfortable with chemistry, doing a nitrogen balance can help you detect nitrification or cross connection problems.

If you see symptoms of nitrification, first check to be sure they aren't masking other problems. For example, check the nitrogen balance in your system.

With all values in mg/L, the nitrogen balance of your system is:

$$\text{FAA } \underline{\text{(as N)}} + NO_2^- \underline{\text{(as N)}} + NO_3^- \underline{\text{(as N)}} + (0.27 \times NH_2Cl) = \text{constant}$$

This number will fluctuate somewhat under normal operating conditions.

If you find that certain areas in your distribution system have high nitrate + nitrite levels and an increased nitrogen balance, then you should check for and rule out cross connections, line breaks, and other sources of contamination before you determine that nitrification is the culprit.

Chapter 1 Review questions

(Questions may have MULTIPLE correct answers.)

What type of process is nitrification?

1. Chemical
2. Biological
3. Natural
4. Man-made

What can contribute to increased nitrification?

1. High free ammonia concentration
2. Lower than normal water temperatures
3. High turbidity
4. Increased levels of nitrate

What are signs that nitrification is occurring?

1. Low total chlorine residual
2. High monochloramine residual
3. Nitrite higher or lower than normal
4. Nitrate higher or lower than normal
5. pH lower than normal

Chapter 1 Checklist

Hopefully, after this chapter, you are more comfortable with the biology needed to understand nitrification, and how to figure out if it is happening.

Make sure by going through this checklist. If there is something you need to work on, note that on your recommended action plan.

Chapter 1 checklist:

<u>Part 1: Nitrification biology</u>

- Do you know what AOB are and what they do?
- Do you know what NOB are and what they do?
- Do you understand the importance of ammonia in nitrification?

<u>Part 2: Presence of ammonia</u>

- Do you understand how ammonia can be present in a distribution system?
- Do you know how the levels of total chlorine and monochloramine change during nitrification? (Do they go up or down?)

<u>Part 3: Detecting nitrification and other issues</u>

- Do you know how the levels of free ammonia change during nitrification? (Does it go up or down?)
- Do you know how the levels of nitrite and nitrate change during nitrification? (Do they go up or down?)
- Can you look at the data and tell whether nitrification is happening or whether something else is causing low residuals?

<u>Next steps:</u>

If you understand nitrification, you are doing great. This understanding will help you learn more about how to interpret data and develop your NAP.

<u>Recommended actions?</u>

If you feel like you did not 'get' it as well as you would like, you may want to schedule follow-up training, or re-read the manual in your own time.
If so, note this on your Plan of Action.

Chapter 2:
Analyzing data to set goals/baselines and triggers

Ultimately, the data will tell you what is going on in the system—but it takes some work to figure out what it is trying to tell you. We will talk about how we can make that process easier.

In this Chapter we will talk about how to look at data in general, look at some examples, and look at this system's historical data to start setting goals/baselines and triggers.

Scope

Goals, baselines, and triggers are the heart of the NAP.

- **Goals/baselines describe the 'good' zone.** These conditions are the desired normal operating conditions.
- **Triggers are a call to action.** When a result is not in the 'good' zone, it is time to figure out what is going on and do something about it.

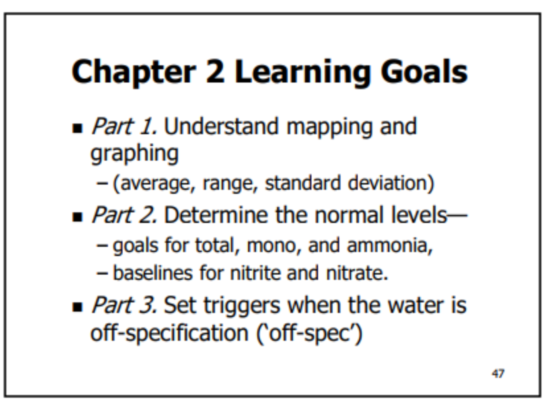
This workshop will go over the process to set goals, baselines, and triggers. You will need your historical data for total chlorine, monochloramine, ammonia, nitrite, and nitrate—plus any other parameters you might use, like pH.

Learning goals

The learning objectives for this Chapter are:

- Be able to determine goals and baselines—
    - 'Goals' for total chlorine, monochloramine, and free ammonia and
    - 'Baselines' for nitrite and nitrate;
- Understand how 'yellow flag triggers' describe the outer bounds of the 'good' zone—they are an early warning that things might be going wrong;
- Understand that 'red flag triggers'
- Evaluate the existing data to determine or estimate triggers; and
- Be able to document goals, baselines, and triggers for the NAP.

If you have historical data, you should be able to set your goals and baselines using that data.



Materials

In this Chapter, we will want to look at:

- This Student Guide,
- The system's historical data, and

The Excel spreadsheet provided:

DAM 8 NAP Data and Template.xlsx

> ***NOTE:***
>
> If the PWS does not have historical data, they need to start collecting it.
> You can't set baselines, goals, and triggers without historical data.
>
> You can get help knowing what to sample by participating in:
>
> ***"DAM 5: Process Management for Systems using Chloramines."***
>
> You can request this training from TCEQ at 512-239-4691, or asking your instructor.

Follow-up

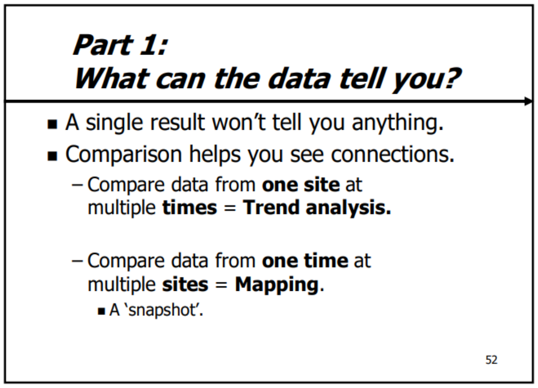
There probably won't be time in this workshop to set the goals, baselines, and triggers for every site for a large system with many sites. In that case, plan to complete that task after the DAM. If you need additional help, request another visit from the FMT contractor by calling the WSD at 512-239-4691.

Period of data?

Generally, the more data you have, the more you can learn. However, using a small portion of the data may lead to more insight. For example, if you are having problems in summer, but not winter, it may be useful to separate the data. Comparing a 'summer map' to a 'winter map' may reveal a pattern that was not seen from just looking at data tables.

Part 1: Data analysis: Mapping and graphing

This is the introduction to the process of looking at the PWS's own data. To get started, let's talk about how we can map and graph the data.



A classic example of how graphs can show that nitrification is occurring is shown in Figure 3 (Slides 52 and 53).

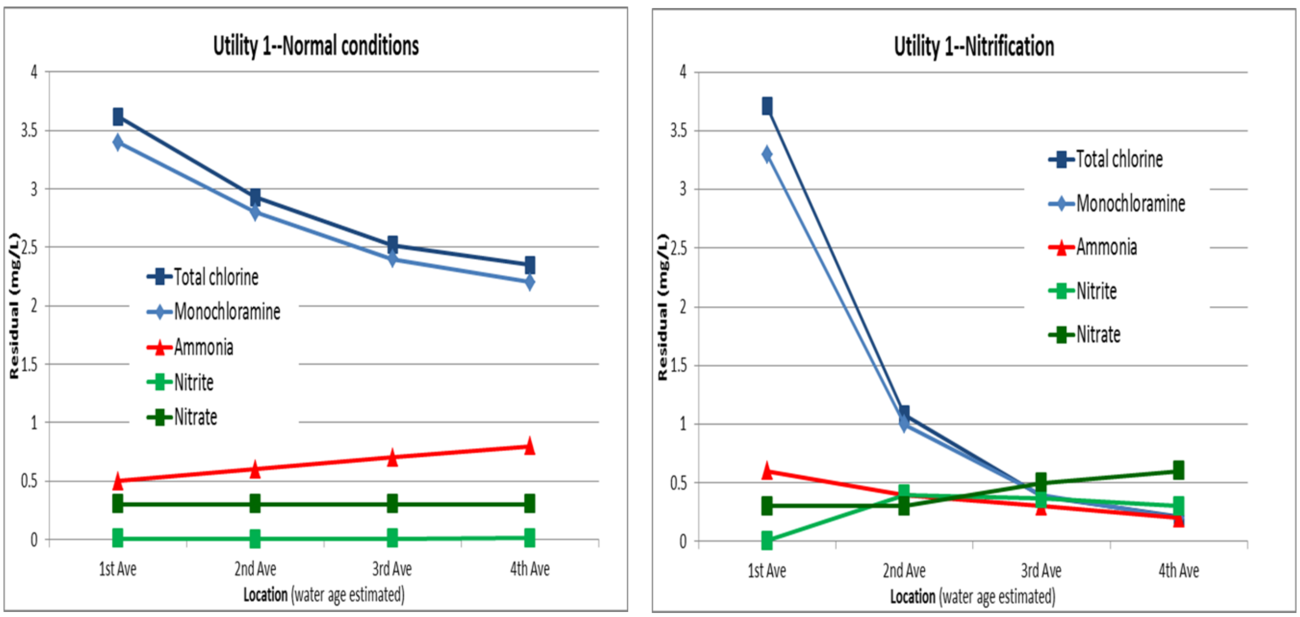


Figure 3: No nitrification occurring (Left), and nitrification occurring (Right) (Slides 52 and 53)

In order to be able to produce a graph like this, the system needs to know how to map and graph data.

Mapping

Mapping the disinfectant residual on the distribution map is a powerful—yet simple—way to understand and control your distribution system. Trends and deviations from 'normal' levels can alert operators to possible problems.

The process is simple—just get a distribution map and write the historical chlorine levels on it. Depending on the amount of data you have, you will need to make some decisions about how much of it to graph.

Mapping and graphing

- To make graphs like the previous ones, you need to have good sites, and map them, so that the graphs are meaningful

55

55

Mapping

- Include:
  - Pipes
    - More prominently than streets
  - Sample sites
  - "Critical control points"
    - Tanks, booster points, flush points, isolation valves
  - Legend, scale, …

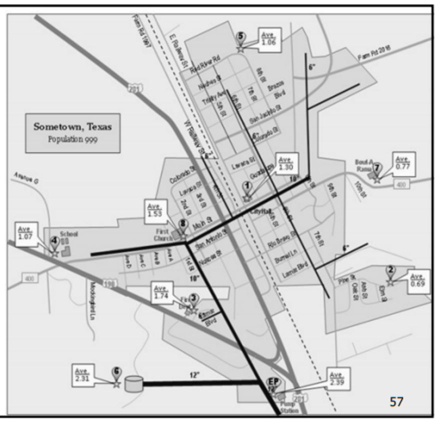
56

56

Example: Sometown, Texas

Mapping chlorine data

(See Student Guide)



57

If there is a lot of data, it can make the map look messy. Using the average is a common way to simplify the data, and the map. However, averages should be taken with a grain of salt, especially if there is a great deal of variation in residuals at a site.

Sometown, Texas—Mapping & Graphing example

Here is the example site table for Sometown, Texas, whose distribution map shown on the next page:

Example of Monitoring Plan Disinfectant Residual Sample Site Table for Sometown, Texas

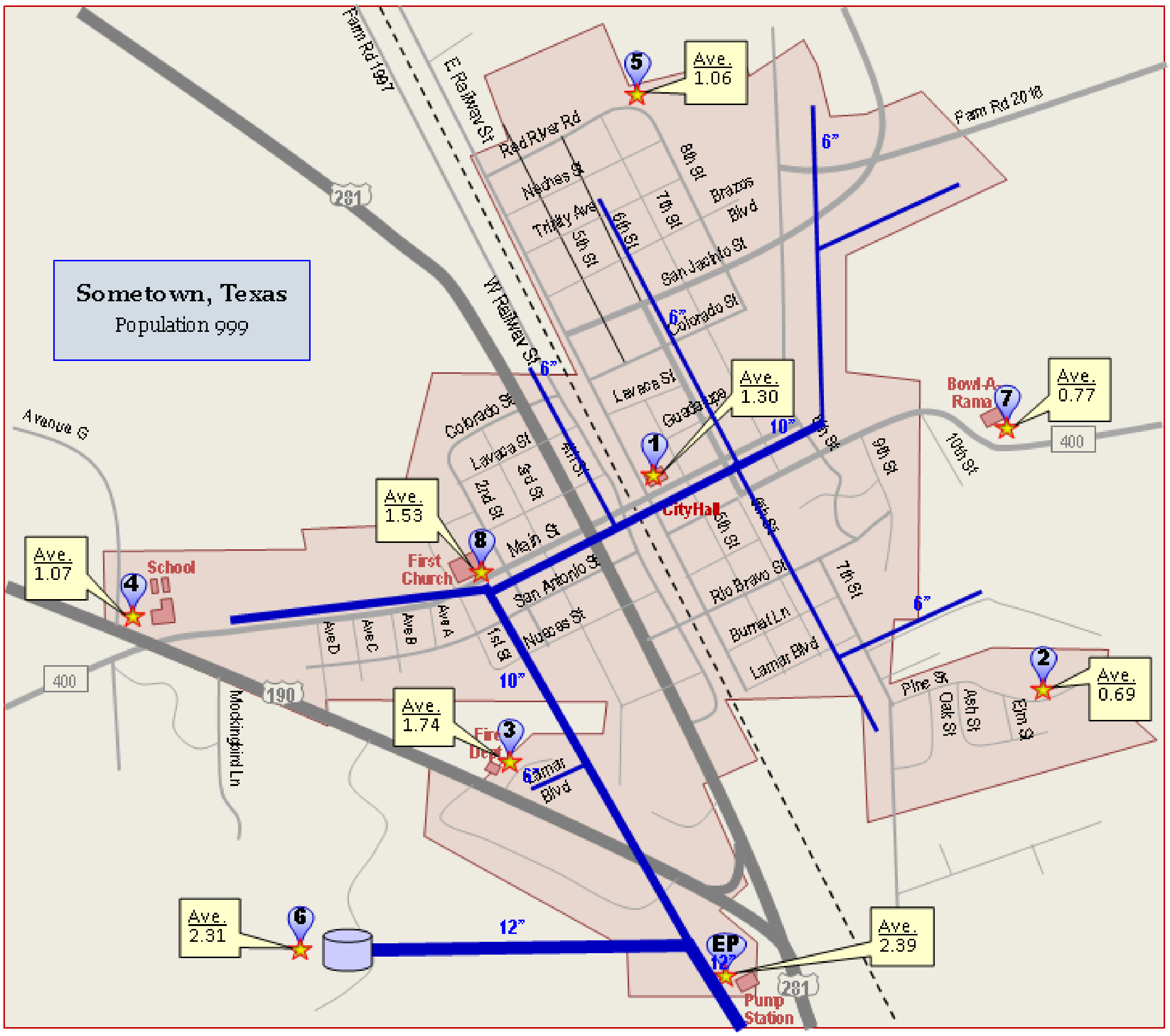
Site # on Map	Address	Sample Tap Location	Water Age	Tap Type	Flush Flow Rate (gal per min)	Calculated Flush Time (min)
EP	281 Pump Station	Tap on Pump 1	Source (0)	Hose bibb	5	5
1	55 E Railway St	Tap by City Hall parking lot	Average	Hose bibb	5	15
2	935 Pine St	Tap in back of house	High	Hose bibb	2	15
3	200 W Lamar Blvd	Fire Department tap by door	Low	Hose bibb	10	5
4	800 W Hwy 190	Tap left of front door of School	Average	Flush valve	5	5
5	700 Red River Rd	Left side of garage	High	Hose bibb	5	5
6	Hill Top Tank	Tap on north side of GST	Storage	Hose bibb	20	5
7	1164 E CR 400	Bowl-a-Rama tap by parking lot	High	Hydrant ID 46	2000	10 (on/off)
8	10 W Main St	First Church - tap left of door	Average	Hose bibb	3	10

Example data from one week is shown in the following table.

One week of total chlorine residual from Sometown, Texas.

Site # on Map	**Date**							**Min**	**Max**	**Ave**
	4/1	**4/2**	**4/3**	**4/4**	**4/5**	**4/6**	**4/7**			
EP	2.1	3.0	2.5	2.7	1.9	2.1	2.4	1.90	3.00	2.39
Site 1	1.4	1.2	1.6	1.5	1.2	1.1	1.1	1.10	1.60	1.30
Site 2	0.8	0.6	0.7	0.8	0.8	0.6	0.5	0.50	0.80	0.69
Site 3	1.5	1.4	2.1	1.9	1.6	1.7	2.0	1.40	2.10	1.74
Site 4	1.1	1.0	1.2	1.3	1.0	1.1	0.8	0.80	1.30	1.07
Site 5	1.0	0.8	1.4	1.2	1.1	1.0	0.9	0.80	1.40	1.06
Site 6	2.0	2.4	2.8	2.7	2.2	1.9	2.2	1.90	2.80	2.31
Site 7	0.9	0.7	0.8	0.9	0.8	0.7	0.6	0.60	0.90	0.77
Site 8	1.7	1.4	2.0	1.7	1.4	1.3	1.2	1.20	2.00	1.53

The map for Sometown, Texas is shown below. The average total chlorine residuals are shown in callout boxes on the map. This is an example of mapping the data.



Example distribution map for Sometown, Texas (slide provided)

EXERCISE:
DISCUSS THESE QUESTIONS ABOUT THE SOMETOWN, TEXAS SYSTEM

Questions for consideration:

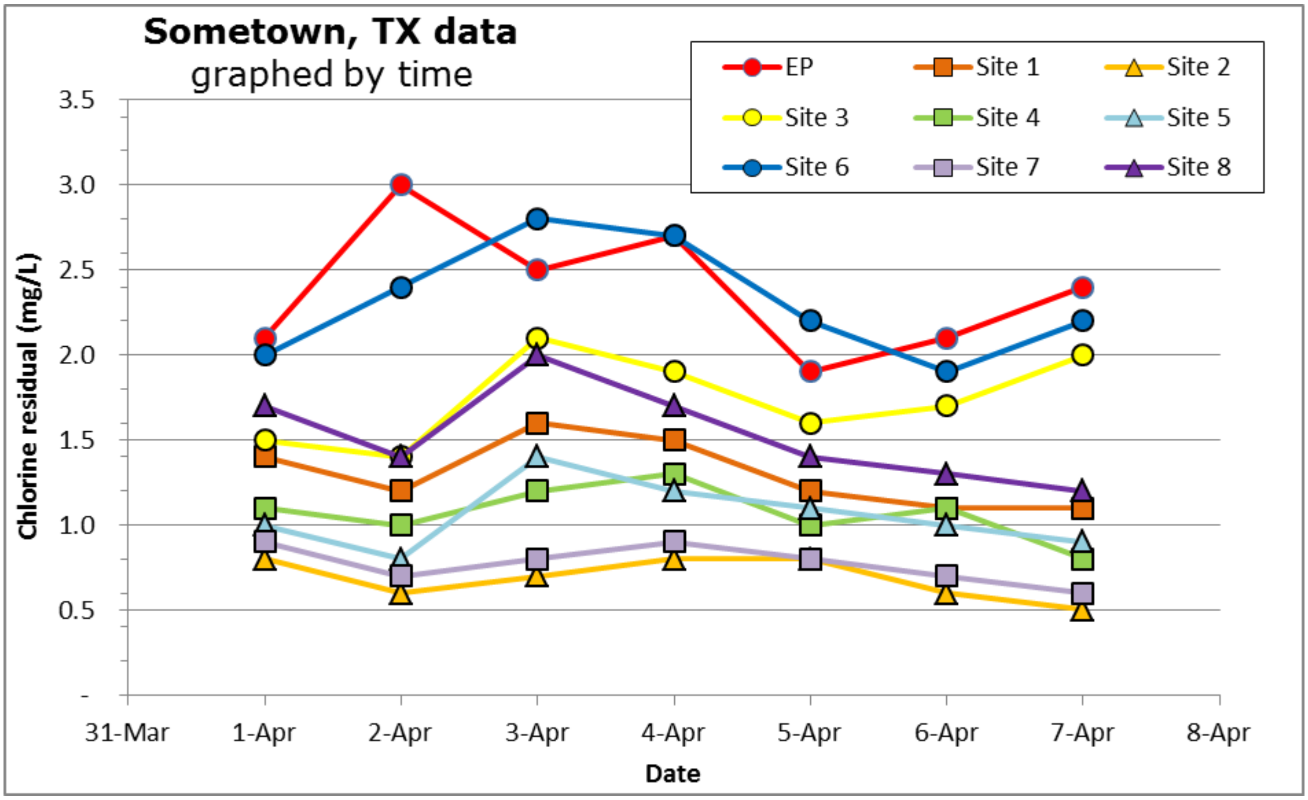
- In the map above, only the averages are shown.
  Would it help you to see minimums? Maximums? Range?
- Does this map draw the attention to the worst-case site(s)?
- When you look at this map, are there any surprises—low residuals where you would expect high residuals?
  High residuals where you would expect low ones?
- Which site is the worst-case site?

- Are there other areas in the system which ought to be sampled just to see if they also have low residuals?
- Are there pipes missing on this map? Does that make it harder to figure out?

Graphing over time

Another way to visualize what is going on with disinfectant residual is by graphing the data. The two main ways to do this are either by time or location.

When looking at a graph over time, you are usually looking for trends at a single site—or comparing the trends for various sites.



Graph of Sometown, TX example data over <u>time</u> (Slide provided)

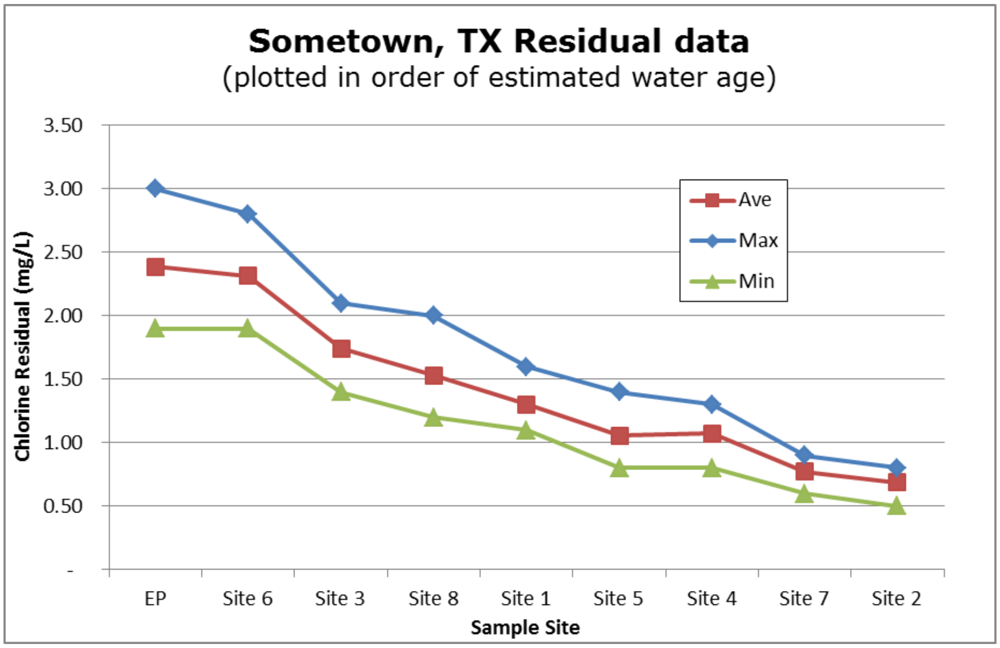
Questions for consideration:

- Can you draw any conclusions from this data?
- For example, can you make some assumptions about water age based on looking at this graph?
- For example, if you compare the Tank location to the entry point, do you see an indication of lag in the water quality?
- If you were sampling weekly instead of daily, how would the graph look different? How would it affect your ability to draw conclusions?

Graphing

With locational graphing, you may be looking for trends related to water age, and comparing those for different locations, or just trying to figure out what the water age is.

In the following graph, the data was sorted by chlorine level from highest to lowest. Since chlorine level corresponds to water age, the site with the lowest water age comes first, and the site with the highest water age comes last.



Example of <u>locational</u> graphing for chlorine residual (slide provided)

Questions for consideration:

- Which site has the lowest water age? Does that match what you saw on the map?
- Is the highest residual at the location you would expect?
- Do you think this might look different if you used a different time period to calculate your average, maximum and minimum?
- Is the range between the maximum and minimum always the same? Does the average always lie exactly between the maximum and minimum?
- In comparison with mapping—do you think seeing the range is helpful?

Part 2. Goals/baselines & triggers

Data characteristics: Average, range, and standard deviation

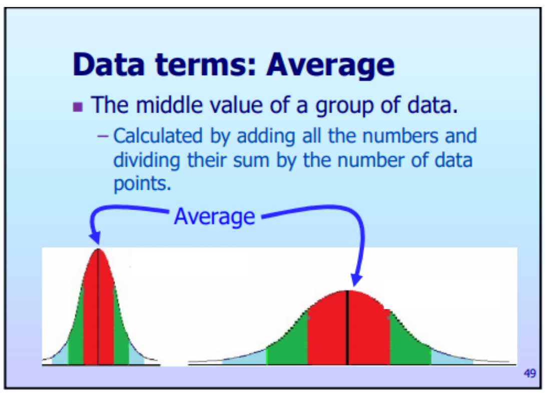
When you are looking at a lot of data, it helps to calculate the average and standard deviation. This is easy to do with a spreadsheet program like MS Excel. Most people are very familiar with the average, but the standard deviation may be new to you. The higher the standard deviation, the more variability there is.

Looking at these data may help you identify issues.

For example, if most sites have very low variability, and one site has lots of variability, it may be worth looking at the variable site more closely. Variability might mean that usage is extremely variable in that area, and more flushing is needed during periods when usage is low.

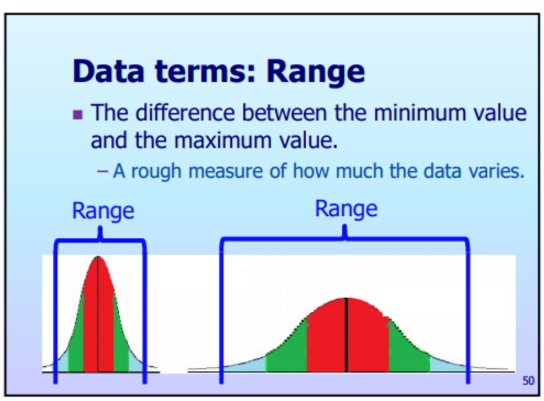
Average

The average is the central point of the data. Even when we try really hard, we probably won't measure exactly the same concentration of, for example, total chlorine over and over—but if the water is stable, our average will be ok.



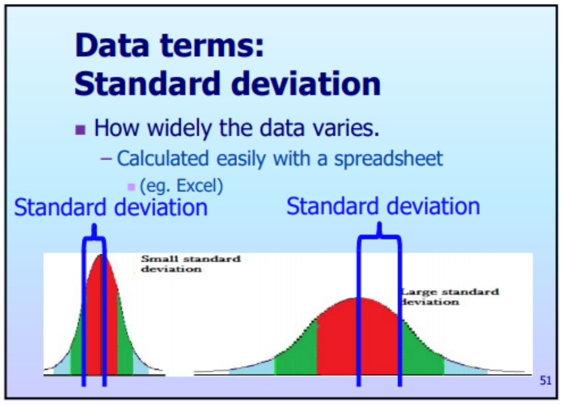
Range

The range is the minimum minus the maximum. It is a rough way of describing how variable the data is.



Standard deviation

The standard deviation is a way of describing how 'spread out' the data is. For example, the slide shows two sets of data—one with a small standard deviation, and one with a large standard deviation.



Just for completeness, the standard deviation is calculated as follows:

- Calculate the simple average of the numbers,
- Then for each number: subtract the average,
- Square the result.
- Take the average of those squared differences.
- Take the square root of that and we are done!

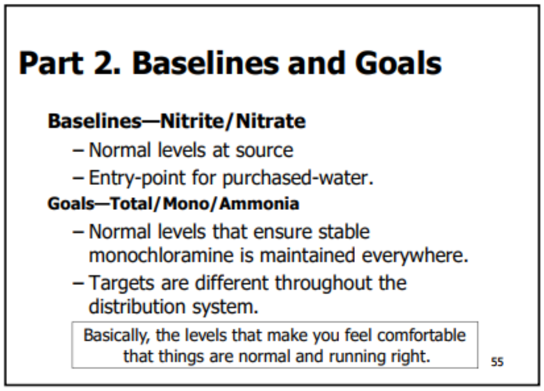
It is a lot easier to use the formula "=StandardDeviation" in Excel or a similar spreadsheet program.

Baselines: The 'green' target

Goals/baselines are the normal, good levels at each point in the distribution system. Initial results and historical data are used to set goals and baselines.

- **'Goals' are set for total chlorine, monochloramine, and free ammonia** to make sure that disinfection is maintained correctly.
- **'Baselines' are set for nitrite and nitrate**, because they come from source water, and are less under a system's control.

Basically, goals and baselines are the same thing, and maybe someday we will just switch and call them all baselines.

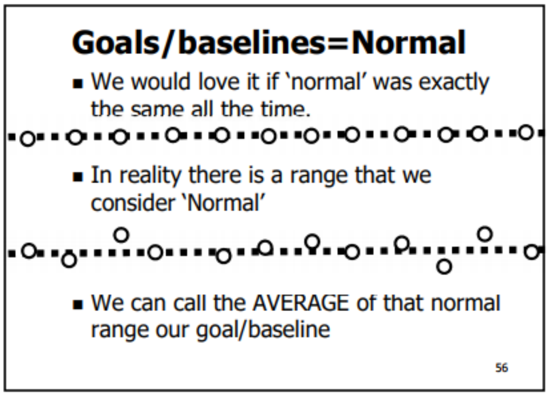


Setting goals/baselines—simple version

Basically, what you want to do is identify the levels that will make you feel comfortable that things are running right, site by site.

1. **The first step is to look at historical data for a site.**
   Are there time periods when you know that nitrification was happening?
   Does it vary a lot? Or is it pretty stable?
   Is it stable at a level that allows water downstream to remain good?
2. **Pick the data for the times when the levels are NORMAL.**
   You are trying to establish a 'good' level—so don't consider data from times when the residual was inadequate.
   If you are working in paper and pencil, make a table of the just values you consider acceptable.
   If you are working in Excel, it might help to make a separate worksheet to hold the goal 'data.'.
3. **Evaluate the average, minimum, maximum, and standard deviation of the subset of data you have picked.**
   Look at those numbers and consider whether that makes sense.
   Is the standard deviation small—like 10 to 20 %--for this data subset?
   Are the minimum and maximum not too far out; are they close to the middle?
   If not, consider throwing out the highest and lowest data point and re-analyze. Repeat as needed.
4. **Select the average of the data under normal, desirable conditions as your goal/baseline.**
   Don't throw out the maximum, minimum, and standard deviations—you will use those to set triggers in the next part of the chapter.

It would be great if 'normal' meant exactly the same thing every time, but in real life, we have some wiggle room. It is just not realistic to expect all of the variability in water to allow us to get exactly the same result from our analysis every single time. That is why we use an average.



After discussing the simple way to set goals and baselines, you can start looking at the example of how that is done

Example. Setting goals for Site #X

In this example, we have data for a sample site called X.
We are going to figure out a good Total Chlorine goal for that site.
First, we gather the data:

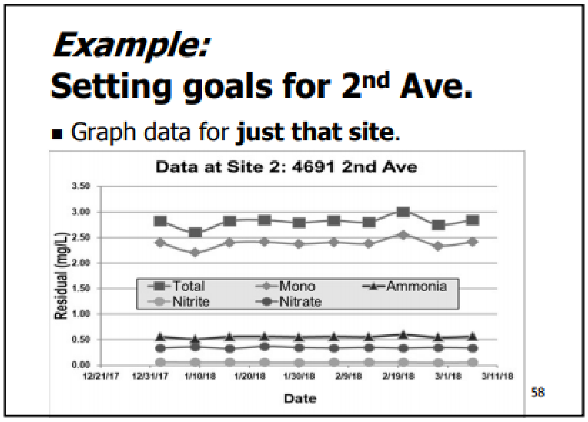
SITE X.

	1/2/18	1/9/18	1/16/18	1/23/18	1/30/18	2/6/18	2/13/18	2/20/18	2/27/18	3/6/18	Ave.	Min	Max	Std.Dev.
Total	2.82	2.60	2.82	2.84	2.79	2.83	2.80	3.00	2.75	2.84	2.81	2.60	3.00	0.10
Mono	2.40	2.21	2.40	2.41	2.37	2.41	2.38	2.55	2.34	2.41	2.39	2.21	2.55	0.08
Ammonia	0.56	0.52	0.56	0.57	0.56	0.57	0.56	0.60	0.55	0.57	0.56	0.52	0.60	0.02
Nitrite	0.062	0.06	0.06	0.06	0.059	0.06	0.061	0.06	0.058	0.06	0.0603	0.06	0.06	0.001
Nitrate	0.34	0.36	0.33	0.37	0.35	0.34	0.35	0.34	0.35	0.34	0.35	0.33	0.37	0.01

Next, we are going to graph the data for that site.

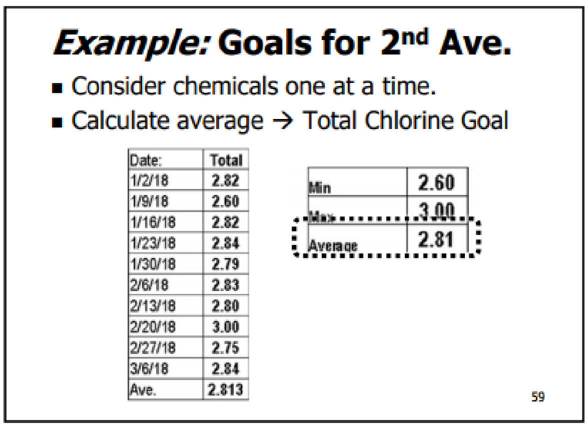
This will allow us to visually assess whether the data is all 'normal' or whether there are dips or hills that look suspiciously **AB**normal.

We **don't** want to use abnormal conditions for setting goals—just normal data.



So, we look at the data and decide that although it varies, we can accept it all as being 'normal' so in this example we won't throw out any data.

Next, we can't analyze all 5 chemicals simultaneously, so let's start by focusing on total chlorine. Here is that data:

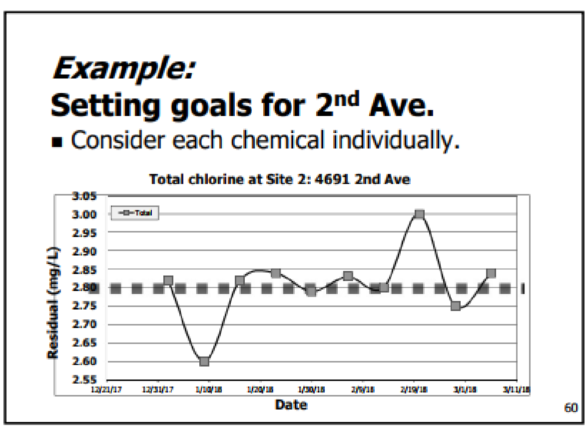


Date:	Total
1/2/18	2.82
1/9/18	2.60
1/16/18	2.82
1/23/18	2.84
1/30/18	2.79
2/6/18	2.83
2/13/18	2.80
2/20/18	3.00
2/27/18	2.75
3/6/18	2.84
Ave.	2.813

Min	2.60
Max	3.00
Average	2.81

Let's go ahead and calculate the average of our data for total chlorine. We do that and get 2.8 mg/L. Looking at the data, that seems good.

This data is graphed below. On this graph, we expanded the Y-axis to make the variability in data pop out better.



Questions for consideration:

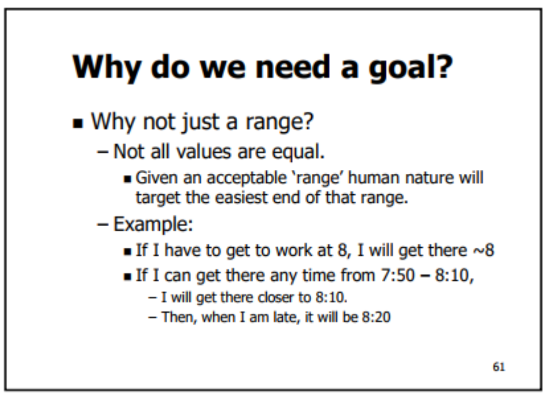
- Do you think that using 2.8 mg/L will be an acceptable goal for total chlorine for this system?
- What data might help you decide, if you are not sure?
- Would you be able to recreate the steps we took to set the total chlorine goal for the other four chemicals?

Why do we need a goal?

Some folks have asked—why have a goal? We have a whole range of acceptable values from the maximum to minimum—doesn't that range achieve our goal of defining the conditions that we will consider 'off-spec'?

There are two reasons to set a goal/baseline:

- Dosing, and
- Human nature.



Dosing

When performing calculations to determine the appropriate dose, it is necessary to aim for ONE number, not a range. Instead of aiming for the maximum or minimum, the operators performing dosing need to have a single number to aim for exactly what they want.

Human nature

When confronted with no goal—just a range, human nature dictates that we will interpret the easiest end of that range as our goal. Thus, instead of aiming for the middle of the range of acceptable values, we will actually take the maximum or minimum as our goal/baseline. Then, any deviation will throw water off-spec and we will either be faced with having to take action more frequently than necessary (or starting to ignore off-spec water and get into trouble with nitrification.)

Additional information: Goals/baselines

During the on-site DAM, the discussion of the example will cover the concepts that are expanded on below.

This additional information is provided so that the student can read more about setting goals and baselines after the on-site visit.

Total chlorine and monochloramine goals

Total chlorine and monochloramine may be about the same, in which case their goals can be set at the same value. However, your water may have some characteristic percentage of total chlorine that is monochloramine

Percentage of total chlorine that is monochloramine

Often, there is a difference between monochloramine and total chloramine. For example, in some water, the monochloramine is always 80% of the total chlorine. In very hard water, the monochloramine may be 110% of the total chlorine. If that difference is always the same, it is 'normal,' and may not be an issue—just a characteristic of your water.

When you are setting your goals, select data sets that have the characteristic ratio of total to mono to use when calculating averages, etc. When the total and mono are NOT at their normal ratio, it might mean that nitrification is happening—you don't want to base your goals on abnormal conditions.

Typical goals for water entering a distribution system range from 2 to 4 mg/L. Most entry point goals are set at a level that will make sure the residual can last everywhere in the system.

Average water-age sites total chlorine and monochloramine goals

Typical goals within the distribution system range from 1 to 3 mg/L. The key for your average goals is to select levels that ensure the area that is represented by the sample site is operating normally.

High water-age total chlorine and monochloramine goals

Most PWSs have goals set for their problem areas. The goal at the far reaches can't just be the minimum of 0.5 mg/L, because any deviation risks a violation. Instead- you need to add a margin of safety, for example 0.7 mg/L. Then you have a safety factor of 0.2 mg/L.

Free ammonia goals

Source water ammonia baseline

Usually, source water does not contain free ammonia. However, wells in central and east Texas and on the Gulf Coast often do. You should sample ***at least*** once to determine whether there is free ammonia in any of your sources.

If you find any significant ammonia (certainly over 0.25 mg/L) you should sample more to find out if it varies. It is easier to set a baseline when you have more data. *(This is called a baseline because you don't have control of it.)*

If multiple sources have different naturally occurring free available ammonia, you will need to figure out what parts of the distribution system each source is present in.

Entry point ammonia goal—SWTP

Ideally, water at entry points just after treatment would have just over zero free ammonia residual because free ammonia is 'food' for the nitrifying bacteria. When you do have a plant, having a trace of free ammonia shows that the water is in the monochloramine zone. Rather than zero, a plant may aim for a very low ammonia concentration at the entry point. A PWS with a treatment plant may be able to achieve this. In that case, an entry point goal for ammonia might be 'as low as possible' without causing unstable chloramines.

However, systems that purchase and redistribute potable water can track, but not control, the water quality at their purchased water entry points.

Purchased water entry point/source goal:

For purchased-water PWSs, the entry point water **is** the source water. The purchased water PWS can't control the ammonia level, but they can measure it and communicate with the seller. Since purchased water may vary, it is recommended that sampling occur **at least** weekly, preferably more.

If the purchaser boosts with chlorine to tie up the ammonia as monochloramine, it is very important to know how much ammonia is available to tie up.

Generally, for a purchased-water system, the ammonia goal will be the average of what the wholesaler provides.

Distribution system ammonia goals:

Free ammonia naturally increases with time. The free ammonia goals in average and high water-age locations should represent good, normal operating conditions. Therefore, the goals in distribution will be higher than the entry point goals.

Use the same data (sites and dates) you used for setting total chlorine and monochloramine goals for setting the ammonia goals. The ammonia goals in distribution will be the average of normal levels.

Nitrite & nitrite baselines

The baseline levels for nitrite and nitrate are the same throughout the distribution system. ***The nitrite and nitrate in the distribution system should always be the same as the source water*** under normal conditions. It only changes if something bad is happening. The only thing that can change nitrite and nitrate is either

- Nitrification,
- Backflow or cross connection, or
- Source water or treatment changes.

This is true unless different portions of the distribution system get water from different sources with different natural levels. The nitrite and nitrate baselines throughout the system are the average concentrations in the source water.

If a PWS has multiple sources, every source's baseline nitrite and nitrate should be evaluated. Then, staff should consider how those sources are used and what areas of the distribution system each source is present in.

If multiple sources have very different nitrite or nitrate levels, it can be complicated.

pH baselines or goals

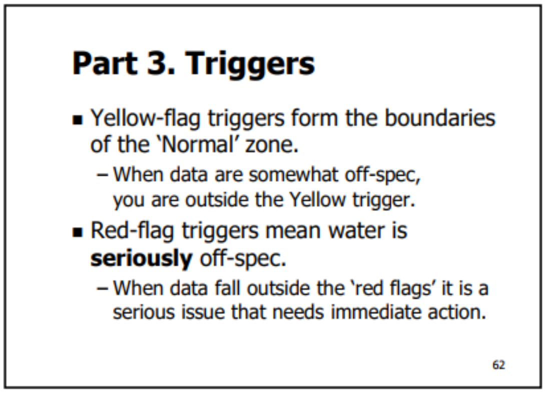
You can use pH as an additional indicator for potential nitrification if you have low alkalinity source water. If so, you should gather baseline pH data. Then, sample periodically for pH—for example at the same time as total chlorine.

(If the PWS adds chemicals to adjust pH, then the normal pH level is a goal—because it is controllable. If the PWS does NOT adjust pH, it is a baseline, because it is out of the operator's control.)

Triggers: Yellow-flag alerts and red-flag alarms

Next, we will talk about setting:

- Yellow-flag triggers, and
- Red flag alarm triggers



Yellow flag 'alert' triggers: Yellow flag levels are somewhat out of the norm, indicating that nitrification may have started. Some action to get back to normal is needed--but it is probably a routine type of action like flushing. (The 'Yellow Flag' triggers describe the boundaries of the 'NORMAL zone' or 'green zone.'

Red flag 'alarm' triggers: Red flag levels happen when it becomes difficult to maintain a compliant total chlorine residual, and there is a strong possibility that nitrification is the culprit. If routine actions don't get the system back to normal, more intense action will be needed.

Setting triggers—The basic process

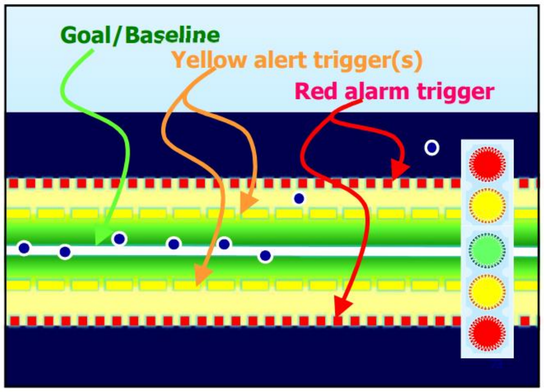
The basic process of setting triggers is different if you have data from a nitrification event, or if you don't.

If you have data from a nitrification event, look at it. Similar to what you did with goals/baselines, you want to extract the data of interest.

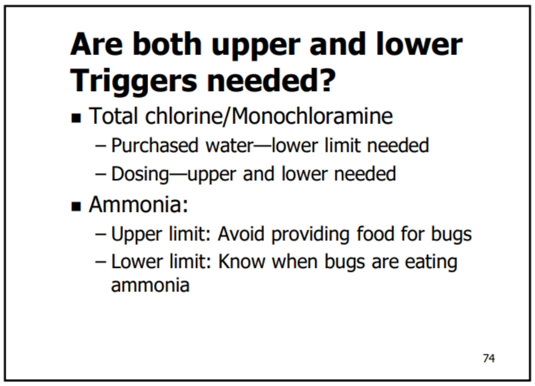
In the step where you set goals, you extracted the data that fell in a 'normal' range. For setting triggers, you want to look for data that suggests 'abnormal' conditions.

Are both upper and lower triggers needed?

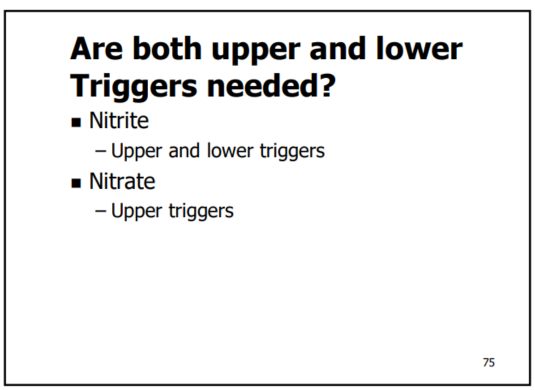
If we were to set upper and lower triggers for one of the chemicals, it would look like this slide. The green 'goal/baseline' would have two bars on its upper and lower limits that would be the 'yellow triggers' and would define the normal range. Then, there would be an upper and lower limit beyond those—'red triggers' defining the limits of the 'yellow' zone.



However, it may not be necessary to set both upper and lower limits for each chemical. In some cases, we are just worried about an upper or lower boundary.



74



It may depend on our operations, but as a rule of thumb:

- ***Total chlorine:*** A lower limit is needed at all sites so that total chlorine does not get so low that the PWS can't meet regulatory limits.

  If a PWS is treating water, it may be smart to set an upper limit also. That will keep the system from spending more money than needed on chemicals.

- ***Monochloramine:*** A lower limit is useful to keep levels from dropping too low. Also, by setting a lower limit for monochloramine, it may be easier to find areas where the chloramines have become unstable, and monochloramine is a lower percent of total chlorine than usual.

An upper limit for monochloramine may be used, but it is not as necessary as an upper limit for total chlorine for systems that are treating the water.

- ***Ammonia:*** An upper limit is used at entry points to avoid overdosing ammonia and providing too much ammonia for the AOB to eat. This is more practical for PWSs that are treating the water.

  In distribution it is important to have lower limits so that when ammonia is too low, you can look for the reason, which may be that AOB is eating ammonia and causing nitrification.

- ***Nitrite:*** It is important to have an upper limit for nitrite so that you can tell if AOB is producing more nitrite than usual. When nitrification gets really bad, NOB will start eating the nitrite and forming nitrate, so it is also important to have a lower limit for nitrite to alert you to that situation.
- ***Nitrate:*** Nitrate will stay the same if everything is normal. It is necessary to have an upper limit in order to show whether nitrate is being formed by NOB.

An additional information section about upper and lower limits is provided after the following example.

Example: Setting triggers for Site X

In this example, we continue to look at the data that was used in the example for setting goals/baselines, but now we are looking at setting triggers.

Example: Setting Total Chlorine triggers for Site X.

To continue our example from the previous part of this chapter, let's consider setting total chlorine triggers for the site at 2nd Ave.

Here, we calculated the standard deviation of the data. The standard deviation is 0.1 mg/L.

The average (and goal) is 2.8 mg/L.

One way we can set triggers is to use the standard deviation, so in this example, we are setting the 'yellow trigger' at one (1) standard deviation less than the goal:

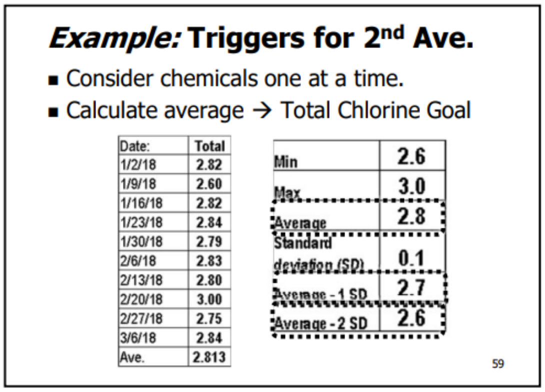
Goal minus one standard deviation = Yellow Trigger

2.8 - 0.1 = 2.7 mg/L

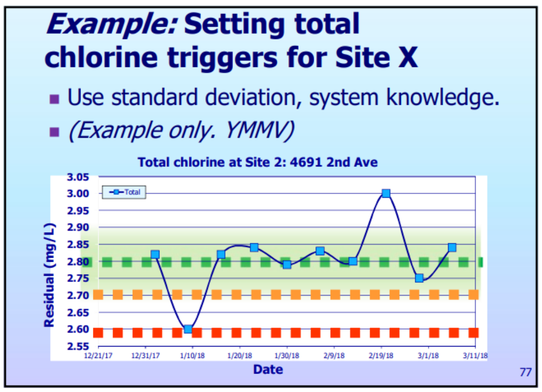
Then, we follow up and set the Red Flag Trigger at two (2) standard deviations less than the goal.

Goal minus two standard deviation = Yellow Trigger

2.8 - (2 x 0.1) = 2.6 mg/L



When we plot this on our graph of total chlorine it looks like this:



Questions for consideration:

- How often will this cause the system to hit Yellow triggers?
  Red triggers?
- Is this an acceptable frequency?
- Can the system hit a Red trigger before hitting a Yellow trigger?

(YMMV: This is one example of setting triggers. You may find a better way to do it)

Additional information: Triggers

During the discussion of the example above, you will consider how to set triggers for total chlorine at one site.

This additional information supports that procedure by discussing the 5 different chemicals and things to think about when setting triggers for them.

Total chlorine triggers

Low-level total chlorine triggers are the most important triggers set by the PWS as part of the NAP.

A system that treats with chloramines may also want to set a high-level trigger for total chlorine to avoid waste and chemical costs.

Total chlorine is the regulated value, so most systems have more data for total chlorine than any other constituent. Therefore, PWSs should have at least a year of historical weekly or daily data to use for setting goals and triggers.

If a nitrification event has occurred, the exact levels where nitrification took place can be used. Otherwise, yellow and red trigger levels should be estimated.

After a nitrification event, the triggers should be reevaluated to see whether different levels need to be held in order to avoid future nitrification events.

PWSs are usually careful to measure the high water-age and high-risk areas to make sure that the total chlorine level throughout distribution is always over the regulatory minimum of 0.5 mg/L.

Monochloramine triggers

Just like for total chlorine, ***low-level triggers are the most important for monochloramine.***

A system that treats the water with chloramines may also want to set an upper level in order to control waste and chemical costs.

Ideally, 100% of the total chlorine should be present as monochloramine. Therefore, under ideal conditions, the monochloramine triggers may be able to be set at the same level as the total chlorine triggers.

Systems may have characteristic ratios of monochloramine-to-total, for example: 80% or 90%. Sometimes this happens because of the two different methods used. PWSs often incorrectly use the high-range DPD method for total chlorine, which gives erroneously high results.

If the portion of total chlorine present as monochloramine changes, it may indicate that follow up action is needed.

Therefore, looking at a lower limit for monochloramine may be very helpful.

Free ammonia triggers

In distribution, the low-level trigger can indicate nitrification; it can indicate that bugs are eating ammonia.

Ammonia naturally increases with water age. Even if water at the entry point has no ammonia, by the time it reaches the end of the system, it will have less chloramines and more ammonia. Ammonia is a field test method and is an extremely important indicator for potential nitrification.

Ammonia will decrease during nitrification. It decreases when the nitrifying bacteria are eating it. If ammonia is lower than the normal goal levels, nitrification is the likely cause.

Ammonia at the entry point should be as low as reasonably possible (but with a little bit to show that you are in the monochloramine zone). Therefore, you may need an upper limit at the entry point, but a lower limit in distribution.

If ammonia *increases* to unusually high levels in distribution, the probable cause is cross connection or backflow.

Nitrite triggers

Nitrite may increase or decrease during nitrification. Therefore, any significant deviation of the nitrite level from normal could indicate nitrification. During the initial stages of nitrification, nitrite will increase; as nitrification progresses, nitrite will drop as it is converted to nitrite.

- **Increase in nitrite:** Nitrite is a critical indicator for potential nitrification because if you see it increase, you have caught the event before it gets all the way to nitrate formation.
- **Decrease in nitrite:** At the point where the nitrite is dropping below baseline, nitrate is probably forming.

Therefore, nitrite goals will have a range: you will need an upper limit and a lower limit.

For example, the normal range (baseline) might be 0.04 to 0.08 mg/L. For that example, a yellow flag alert trigger might be plus-or-minus 20%, which would be under 0.032 mg/L or over 0.84 mg/L.

A red flag alarm trigger might be plus-or-minus 50%, which would be under 0.02 mg/L or over 0.16 mg/L.

Nitrate triggers

Nitrate increases when nitrification is very bad. If nitrification has progressed to the point where nitrate is forming, it is far advanced. Only an upper limit is needed for nitrate.

The only possible reasons to for nitrate to increase are:

1. Nitrification,
2. Cross-connection, backflow, or backsiphonage of sewage or fertilizer,
3. Source water contamination.

Any of these is a major issue.

pH triggers

The pH drops when nitrification occurs. If the buffer capacity of the water is too high (high hardness or alkalinity) then this will be less noticeable. If you choose to use pH for a trigger, set triggers lower than the normal level.

If you have pH data, go through the same general process for setting goals and triggers.

Goal/Baseline and Trigger Exercise

The following exercise has you go through the rest of the data for Site X.

If you have data for the actual system, the instructor may skip this exercise and go straight to the following 'Assignment' to look at the actual system data.

Exercise. Setting other goals for Site #X

This exercise goes through the other parameters for Site X.

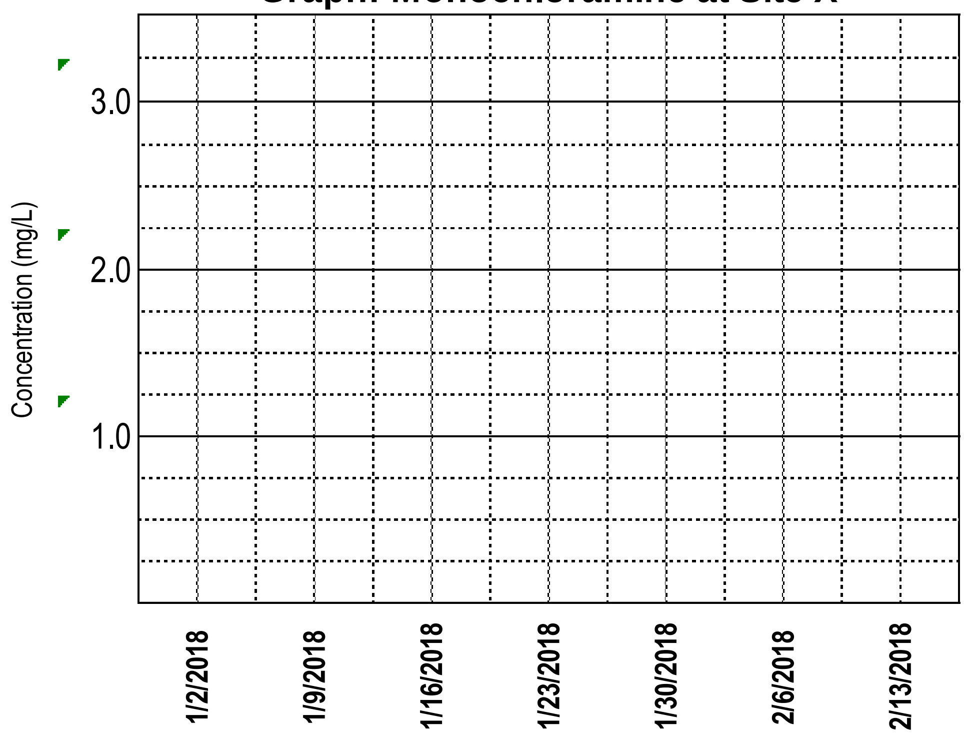
Use the data in the table below to set goals/baselines and triggers for this site if you don't have specific site data available to work with, or if the group has more than one system in it.

SITE X.

	1/2/18	1/9/18	1/16/18	1/23/18	1/30/18	2/6/18	2/13/18	2/20/18	2/27/18	3/6/18	Ave.	Min	Max	Std.Dev.
Total	2.82	2.60	2.82	2.84	2.79	2.83	2.80	3.00	2.75	2.84	2.81	2.60	3.00	0.10
Mono	2.40	2.21	2.40	2.41	2.0	2.41	2.38	2.55	2.34	2.41				
Ammonia	0.56	0.52	0.56	0.57	0.56	0.07	0.56	0.60	0.55	0.57				
Nitrite	0.062	0.06	0.06	0.06	0.059	0.06	0.0061	0.06	0.058	0.06				
Nitrate	0.34	0.36	0.33	0.73	0.35	0.34	0.35	0.34	0.35	0.34				

Monochloramine

Graph: Monochloramine at Site X



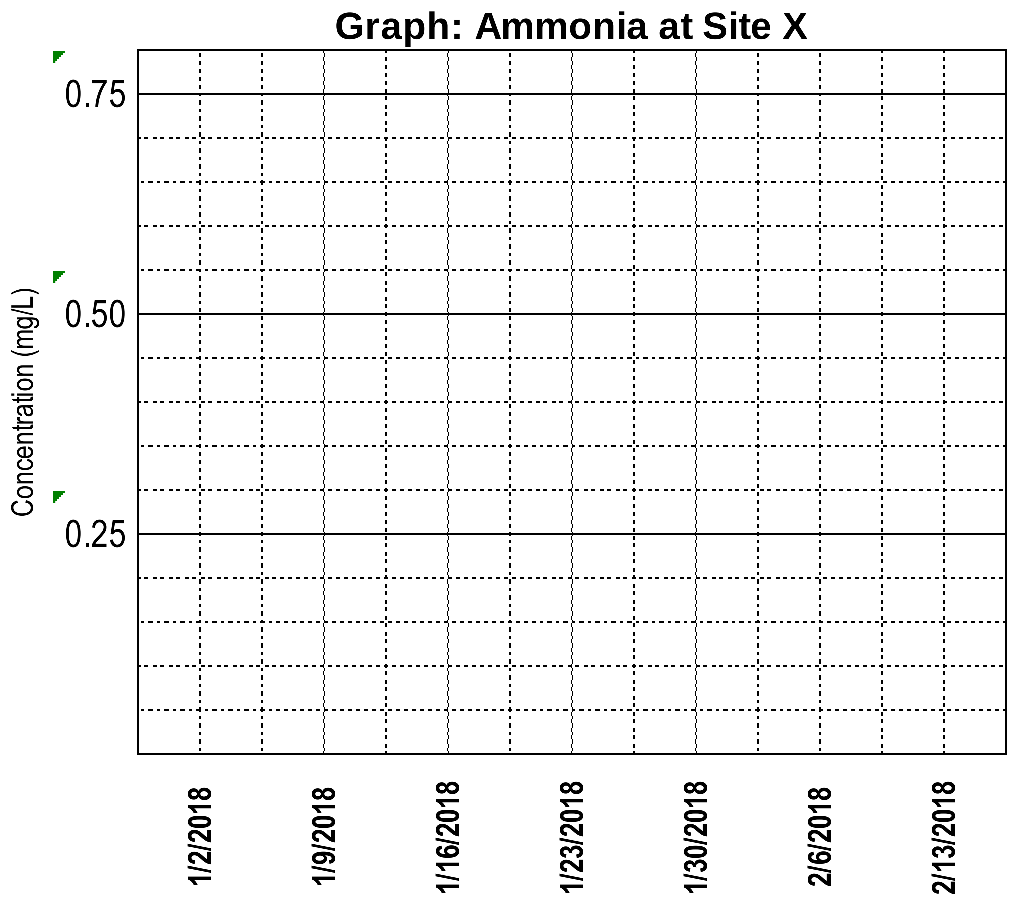
What is your selected Goal ___________,

Yellow trigger ___________

Red trigger ___________

How did you select those?

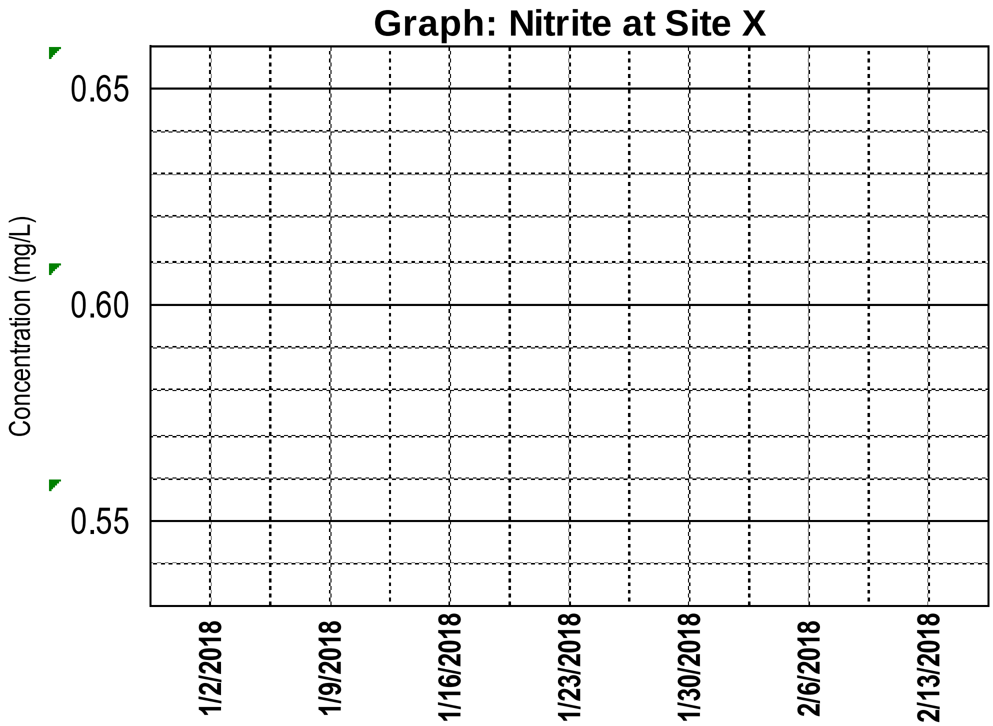
AMMONIA



What is your selected Goal ___________,
Yellow trigger ___________
Red trigger ___________

How did you select those?

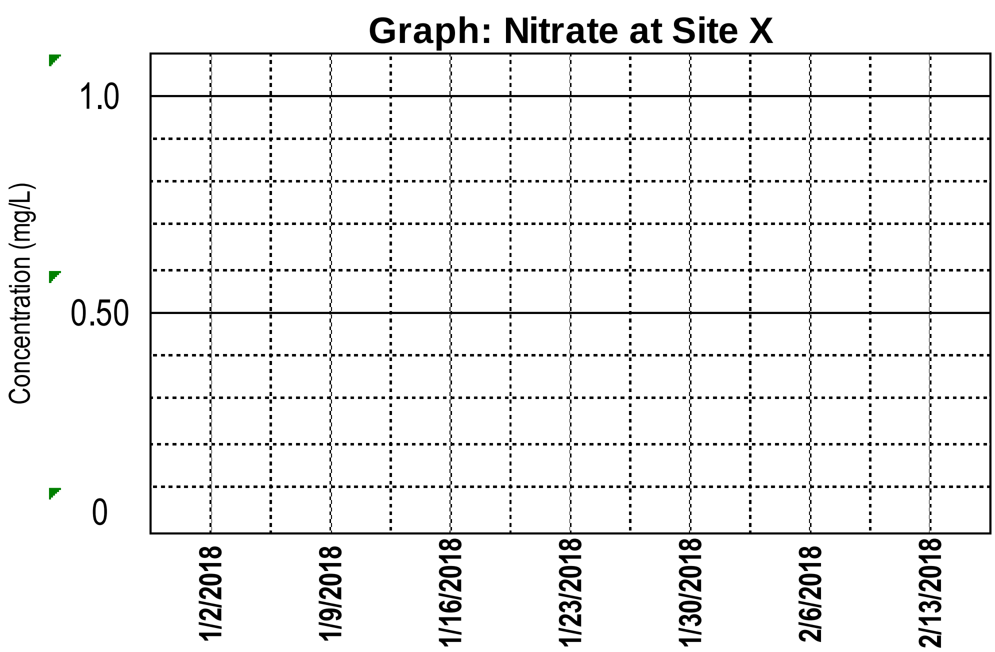
Nitrite



Baseline: _________, Yellow trigger: _________Red trigger: _________

How did you select those?

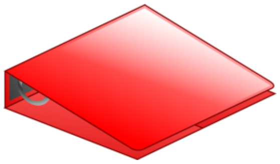
Nitrate



Baseline: _________, Yellow trigger: _________Red trigger: _________

How did you select those?

Assignment: PWS-Specific hands-on activities



The best way that this DAM can help you develop a NAP is to look at the PWS's own data.

Gather all pertinent data for each NAP site. If you are missing data, make a plan to collect it.

Ideally, use an electronic spreadsheet, and use separate worksheets for each site, or group of sites, depending on the system size.

Go through the process of setting goals, baselines, and triggers for at least three sites:

- one source or entry point,
- one average site, and
- one maximum water age (or other issues) site.

Make a plan for completing that process for the rest of the NAP sample sites.

Goals—for total chlorine, monochloramine, and free ammonia

Gather the total chlorine, monochloramine, and ammonia data for each site. Either enter the data in a spreadsheet program, or make tables by hand.

Use Excel

Open Excel and graph the data. You can use the provided worksheet:

DAM 8 NAP Data and Template.xlsx

Select the data that you consider 'normal' conditions.

- **Entry points:** For example, you already have a pretty good idea of what total chlorine you want to hold at an entry point to keep a residual throughout the system. Check to see whether the entry point data lines up with your expectations.
- **High water age/problem areas:** The places you have the most trouble holding a residual may be high water age or just old, crummy pipes. You probably have a goal set for these areas. Look at the data and see how you are doing. Update your goals if needed.
- **Average sites:** You may have looked at your total chlorine data to choose average sample sites in Chapter 1. Repeat the process of looking at the data, finding the most reasonable, lowest values that you feel comfortable will represent good, normal conditions.

For each site, and each chemical, set goals. If you can't do all the sites, make a plan for completing them later.

Baselines—for nitrite and nitrate

Gather the nitrite and nitrate data for each source and/or entry point. Make tables and graphs. Determine a normal range—for example, the average p

If there is only one source, the nitrite and nitrate baselines will be the same throughout the system.

If you have multiple sources, consider how they are blended. For example, if two wells with different nitrite and nitrate levels blend before an entry point, consider how they are operated—and review the data—to determine what the highest range is. Use a spreadsheet and graph the data if possible.

Triggers—yellow and red flags

Review the data for each site. If a nitrification event has occurred, consider the levels during the event. If not, make estimates of triggers and set a future date to review additional data to reconsider your estimates.

Chapter 2 Review Questions

(Questions may have MULTIPLE correct answers.)

<u>What are goals and baseline intended to represent?</u>

1. Highest allowable levels
2. Lowest allowable levels
3. Normal, acceptable levels

<u>What statistical equation can be used to set a goal or baseline?</u>

1. Standard deviation
2. Average
3. Mean
4. Median

<u>What are triggers meant to do?</u>

1. Make a gun fire
2. Alert water system staff to take some action
3. Trigger public notification

<u>What statistical equation can be useful for initially setting triggers?</u>

1. Standard deviation
2. Average
3. Mean
4. Median

<u>Trigger levels for total chlorine should be the same at every sample site:</u>

1. True
2. False

Chapter 2 Checklist

Data Analysis

- Do you understand mapping and graphing data to evaluate data?
- Do you have a way to map your data?
- Do you have a way to graph your data?

Goals/baselines

- Have you set goals and baselines for all five chemicals?
  - At all entry points?
  - At critical control points?
  - At average and high water-age?

Triggers

- Have you set yellow alert and red alarm triggers for all chemicals and all sites?

Follow up:

If you have set goals, baselines, and yellow and red triggers for all your NAP sites, you are almost done producing a successful NAP sampling plan.

If you still need to set some goals and triggers—especially if you need to collect some more data, make a plan for that and write it down on your follow-up plan.

At this stage in the training, you are more than halfway done. In the next workshop, you will discuss how to choose actions to take when you bust a trigger.

Chapter 3:
Actions

Scope

We have learned how to identify what results might indicate nitrification.

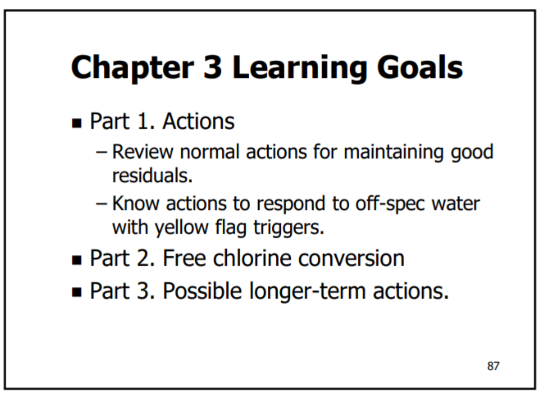
We have learned how to choose goals/baselines and triggers.

Now, let's consider what actions should be taken when the water quality is 'off-spec'—does not meet the goal/baseline and triggers a red or yellow flag.

Learning goals

For every trigger, you should identify what you are going to do when you see it. As the situation becomes more critical, the actions are more extreme. Learning objectives for this workshop include:

- Know how to respond to 'yellow flag' and 'red flag' triggers,
- Understand the common sequence of actions to:
  - Verify the results,
  - Eliminate sample tap problems,
  - Identify the affected area,
  - Flush the local area to bring stable water with an adequate residual in,
  - Perform unidirectional flushing (UDF), and, if needed,
  - Perform a temporary conversion to free chlorine.



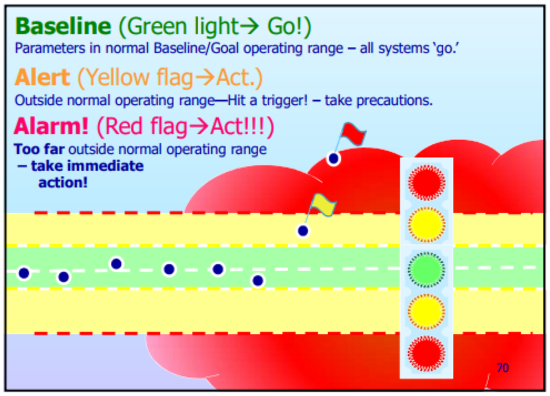
Materials

The materials used for this section of the training include:

- ✓ The Student Guide,
- ✓ The system's data and Standard Operating Procedures.

Part 1. Common actions!

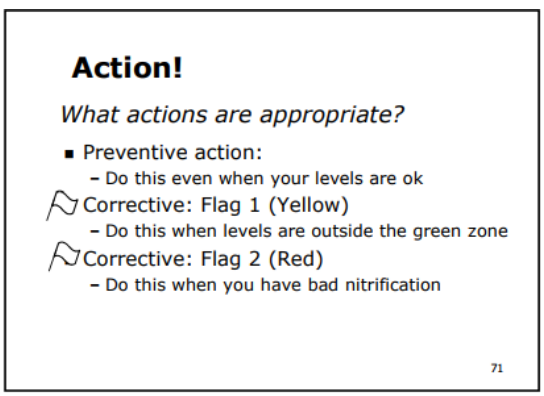
The ultimate purpose of the NAP is to ensure that actions are taken to avoid nitrification in the first place, and then to be able to respond to it when and if it happens anyway.



In this section, we will talk about those actions.

The three types of actions

There are actions you do every day, and other actions you take under unusual conditions. Sometimes it is just a matter of degree—for example, you do flushing all the time, but more if you get a red water complaint.



● Normal operations:

A fundamental part of the NAP is to have normal operating procedures that keep things running right. When disinfection is going well, preventive actions are used to keep it going that way.

● Yellow flag 'alert' actions:

When your nitrification indicators hit yellow flag levels--some action is needed to get back to normal is needed. Often these corrective actions are similar to the preventive actions--like sampling and flushing.

● Red flag 'alarm' actions:

When the total chlorine residual drops to low levels, nitrification may have progressed far enough that more extreme measures are needed to get back on track.

If not, there may be another problem like cross-connection or treatment failure that needs attention.

Note: The TCEQ provides these examples of actions for guidance only.
Each PWS that uses chloramines must select actions appropriate to its unique circumstances and must document those choices in the NAP.

Normal operations for controlling nitrification

Very generally, the NAP concept is to prevent severe nitrification events by:

- Not providing free ammonia as a food source for nitrifying bacteria in the first place;
- Detecting indicators of nitrification at the earliest practical time;
- When indicators of nitrification are found, taking action to eliminate it; and
- After a nitrification event, trying to find the cause to prevent it from happening again.

Basic ways to avoid and control nitrification:

Control the chlorine-to-ammonia ratio during treatment**:**

- To avoid nitrification, control the chlorine to ammonia ratio at the treatment plant or at booster treatment plants in the distribution system.
- Ensure that the monochloramine is stable, not in the di-/trichloramine zone.
- Ensure that there is adequate mixing when dosing.

Control water age to prevent nitrification:

- Avoid constructing dead ends. When possible, eliminate these dead ends.
- Identify and eliminate hydraulic dead ends.
- Inspect, clean, and maintain all potable water storage units in the plant and distribution system.
- Deep cycle storage tanks routinely to prevent stagnation: ensuring that the stored water is not older than desired.

Keep distribution pipes clean:

- When flushing, consider both the flushing rate and the length of the flush.
- Monitor and record residuals when flushing.

Cause of problem?

Failure of these routine, preventive measures may be the cause of off-spec water, for example:

- Low use in the affected area.
- Tanks not being deep-cycled.
- Unstable chlorine and ammonia ratios.
- Flushing is inadequate, valves are closed when they shouldn't be.

First step: Sample verification

In all cases, green/yellow/red… the first step is to make sure that the information that you are basing decisions on is correct. For potential nitrification, this step means taking additional samples.

Figure 3 shows a flow chart for verifying sample results before taking follow-up actions.

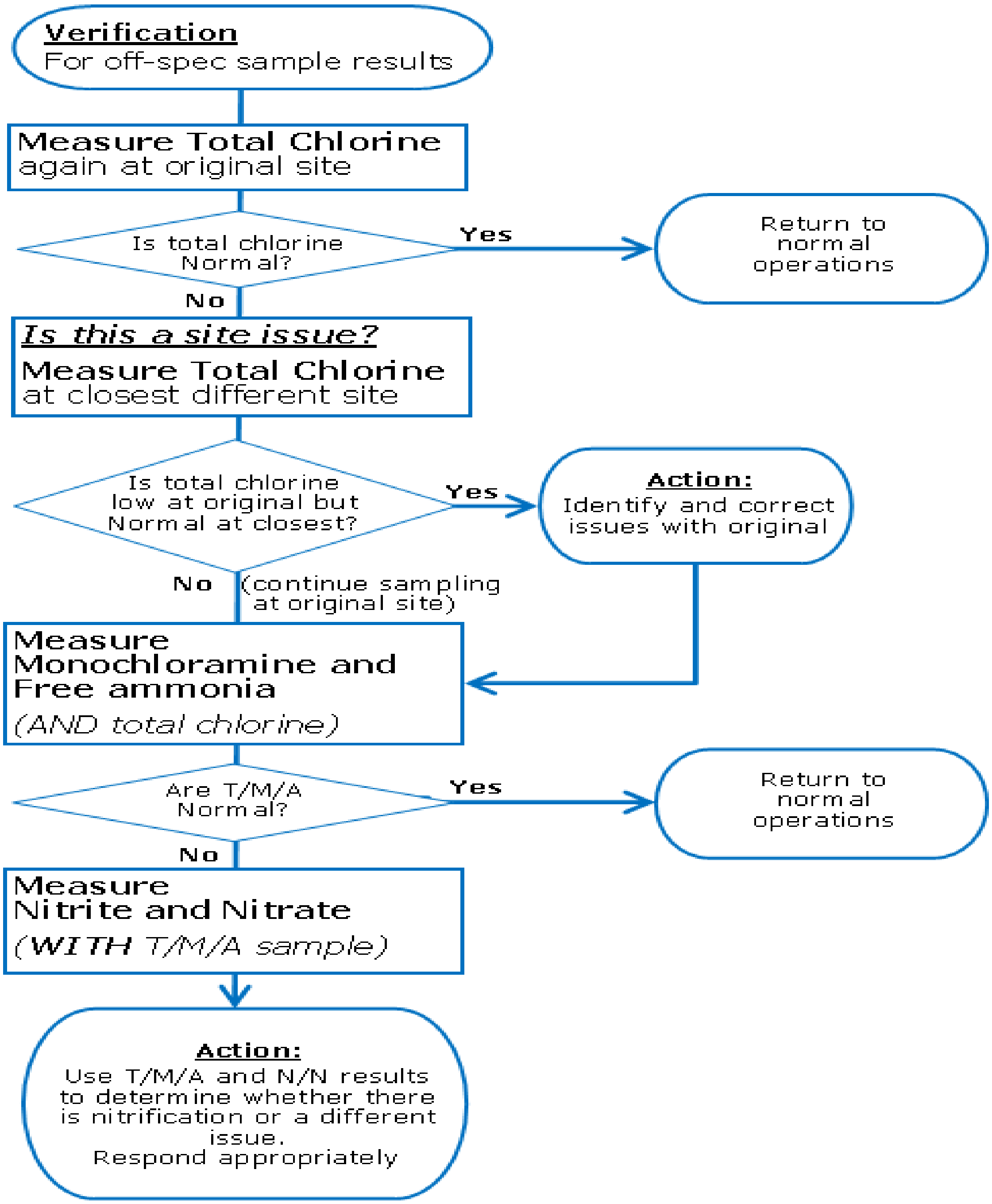
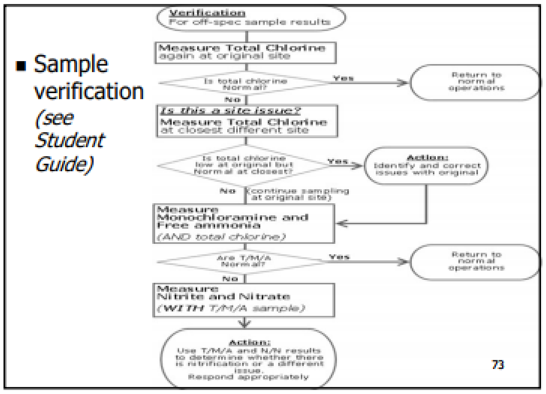


Figure 3. Verification sampling flow chart



Yellow-alert corrective actions

When a single sample is out of the 'good zone', operators take action to ensure that it does not indicate runaway nitrification—or, if it does indicate nitrification, they take action to stop the nitrification.

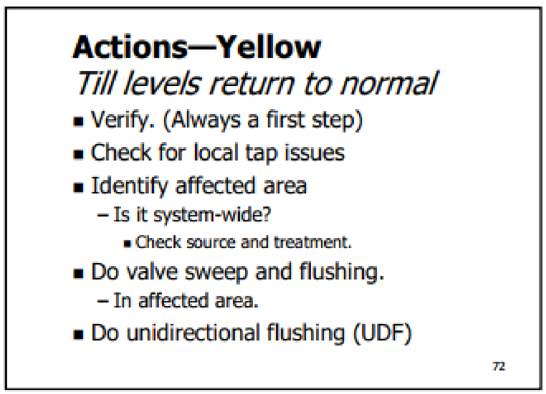
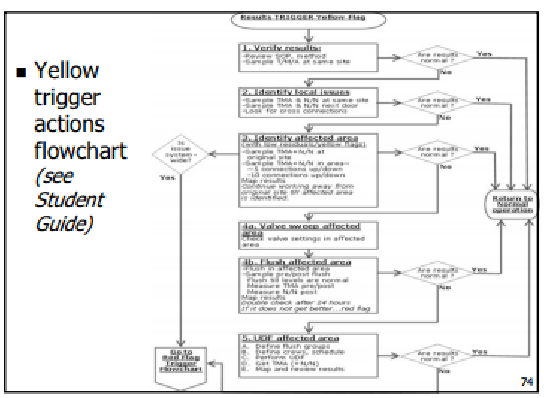


Figure 4 shows the flow chart of 'Yellow Flag—Alert!' actions.



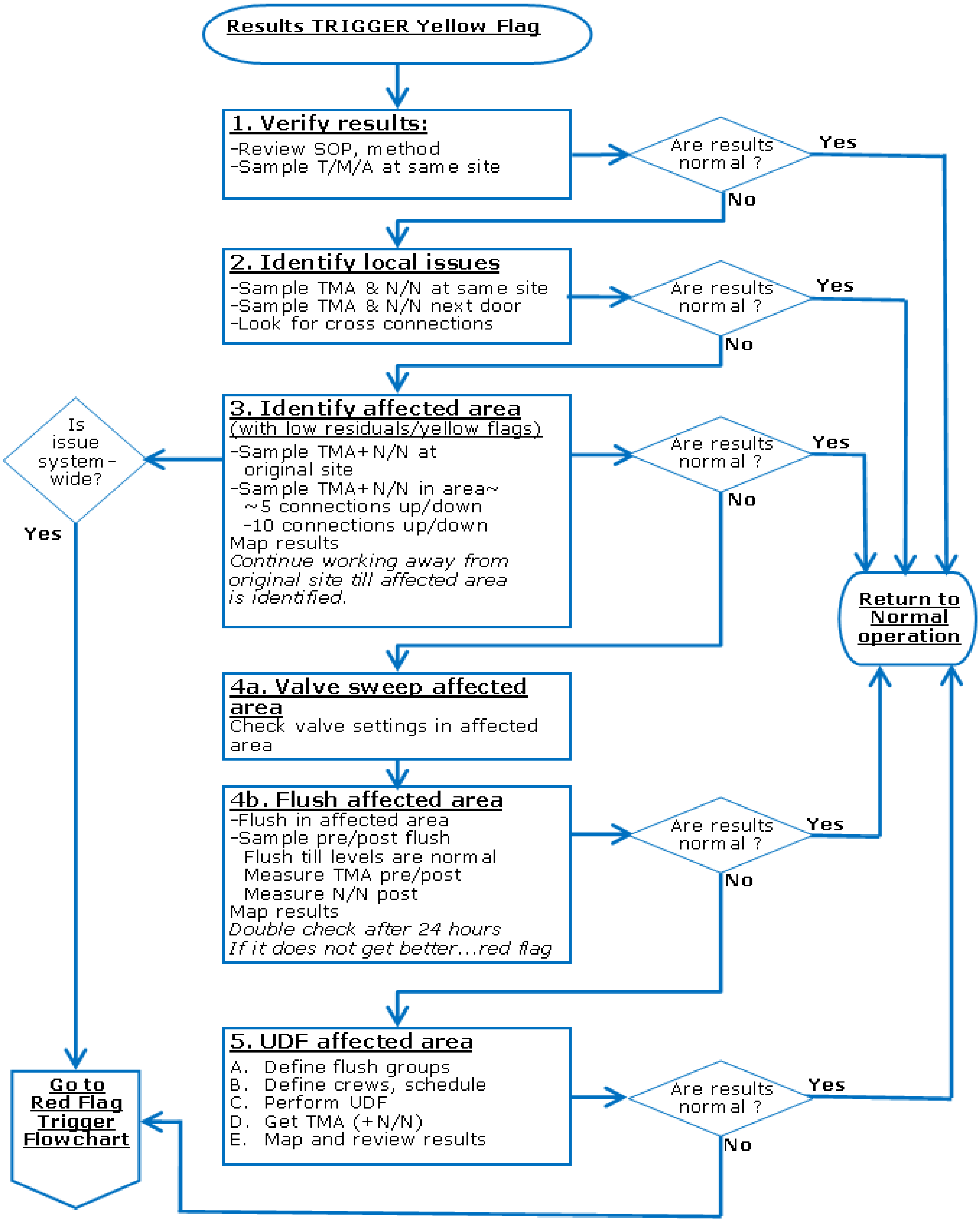


Figure 4. Simple flowchart of Yellow Flag response actions for any PWS.

Sample verification

● Before making a decision on what further action to take--it's a good idea to double-check the first measurement.

● It is a good idea to double-check accuracy routinely, to document the variability of the analysis method.

This is the most common action.

Nitrite/ nitrate sampling

● Nitrite is a key indicator of nitrification. If chloramine-effectiveness measurements are off-spec, nitrite and nitrate sampling are necessary to determine if nitrification is happening.

● Although the rule only requires 6 samples to set baselines, more nitrite and nitrate data will improve your ability to respond to potential nitrification.

Verification and extra nitrite/nitrate sampling are the most common actions. Figure 5 shows the flow chart for the procedure of verification sampling.

Determine affected area

● Nitrification is a biological process, so it can 'bloom' in one portion of the distribution system while other areas remain okay. Determining what area is affected will allow a targeted response to effectively stop the nitrification.

Valve sweep

●● Often, valves get left in the wrong position. It just happens. When a valve that should be on is off, it can create a mini-dead end inside the system. Checking the valves by doing a 'valve sweep' near the place that triggered allows you to find, exercise, and correctly set valves to make sure the water is flowing the way you want.

Flushing

● Every PWS is required to flush every dead-end main (DEM) every month.

● Flushing can bring fresh water with a strong chloramine residual to a location where disinfectant levels are decreasing. However, it is only a short-term solution because of the conservation, economic, and customer relations impacts.

Unidirectional flushing

●● Unidirectional flushing (UDF) is a way of organizing flushing to achieve a velocity of 5 feet-per-second (FPS) in the pipe. At 5 fps, suspended sediment is effectively removed. UDF can be used to target a problem area.

Flush at a rate that provides a line flow rate of at least 5 feet per minute. (Your distribution system should be designed to accomplish this and still maintain a line pressure of 35 psi.)

Flush long enough to ensure that the any material stripped from the pipe walls is flushed out. The flush time will vary from flush valve to flush valve. This may take a couple volumes of the affected part of the line being flushed.

Because the flushing is being performed to resolve a problem (elimination of early indicators of nitrification or response to a water quality complaint) the flushing routine should include pre- and post-flushing testing for total chlorine, monochloramine and free available ammonia residuals (unless you are under a free chlorine conversion).

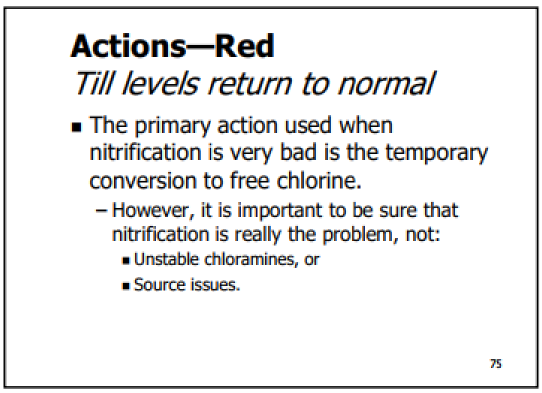
Communicate

When you find and verify results that trigger a red flag, you should be sure to communicate that to managers or operators who need to know about it.

Additional flushing, tank cycling, and other actions can take lots of time and resources. Managers and operators need to know what to expect. We will talk more about that in Chapter 4.

Red-flag alarm corrective actions

Sometimes, you catch nitrification at the yellow alert stage… Other times, it can get past you. Then, the number of follow up possibilities is more limited.



When a nitrification event is occurring, operators have fewer options.

For minor events in isolated areas, the first thing folks do is flush, to try and bring fresh water with a good chloramine residual into the affected area. As with “preventive” flushing, both the flushing time and the flushing rate is important.

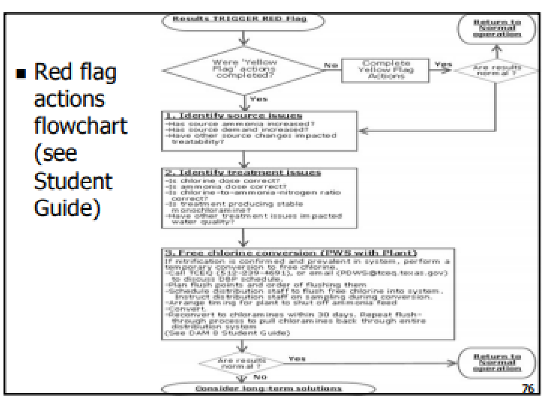


Figure 5 shows a flowchart of ‘Red Flag! Alarm!’ actions.

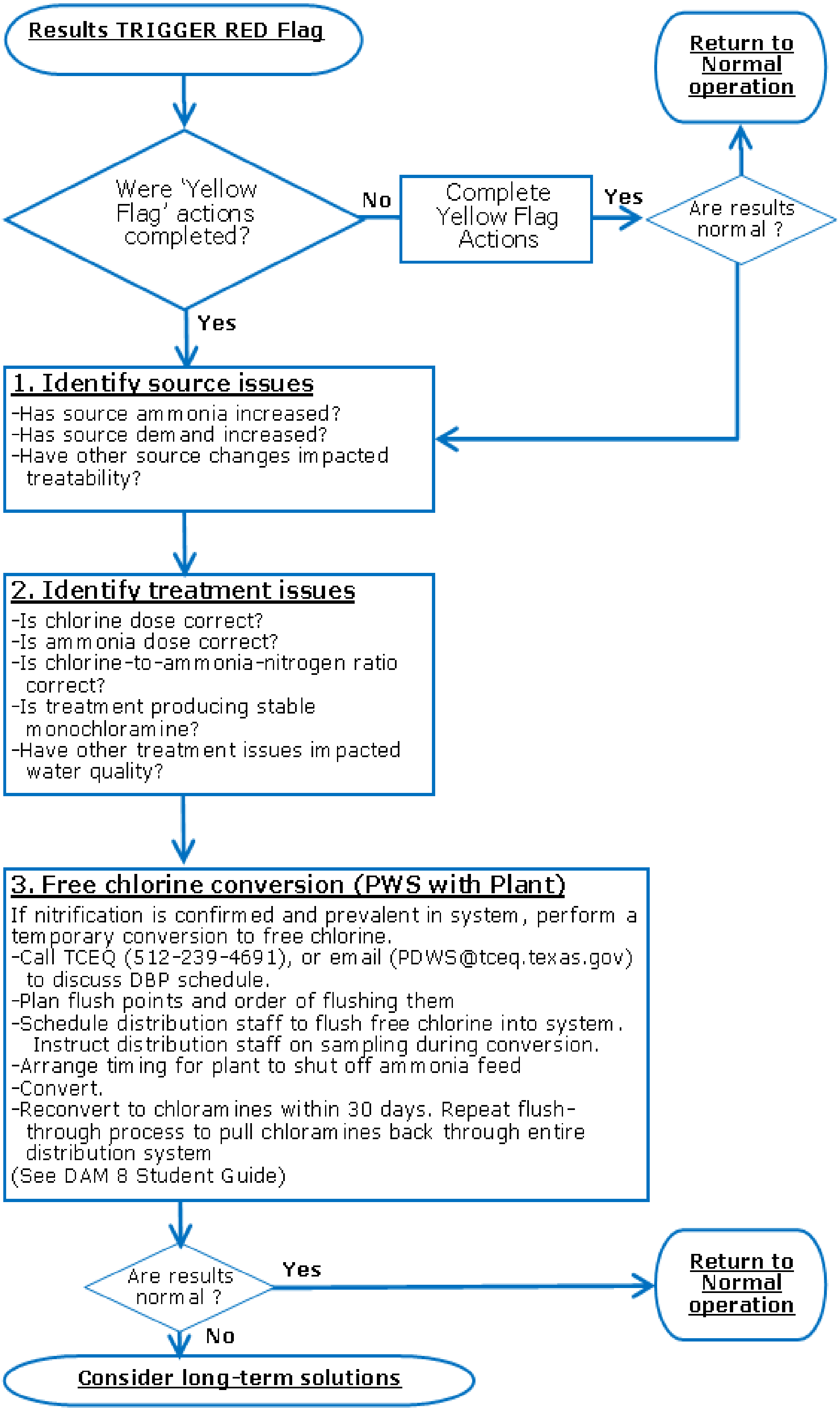


Figure 5. Simple flow chart of Red Flag ALARM!!! Actions for any PWS.

Communicate—The next chapter covers this

The first thing to do when you find results that trigger a red flag is to communicate that to managers or operators who need to know about it.

Free chlorine conversion—The next section covers this

●● Free chlorine conversion is often called a 'burn,' 'shock,' or 'refresh.' When free chlorine is present, it starves nitrifying bacteria. Although a free chlorine conversion is sometimes thought of as an extreme measure, there are numerous PWSs that perform routine, annual free chlorine conversion as a preventive measure.

●● E-mail the TCEQ at *DBP@tceq.texas.gov* 30 days before doing a free chlorine conversion.

● Free chlorine conversion is often used to respond to nitrification.

Contact TCEQ at 512-239-4691 or *DBP@tceq.texas.gov* to discuss scheduling a free chlorine conversion.

The next part of this chapter discusses free-chlorine conversion in greater depth.

Pigging

●● Pigging is the process where a cylindrical 'pig' is forced through a water main with hydraulic pressure, forcing sediment to be scraped off the walls then removed at a flush point. Pigging is best used where the system has been designed with entry and exit points for the pig. Pigging is not considered practical for old, weak pipe.

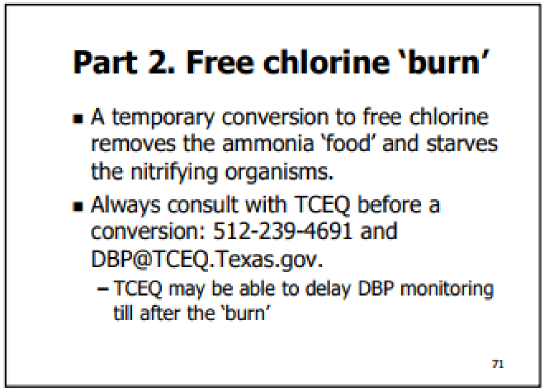
Pigging is not shown in the flow chart because your system generally needs to be originally designed for pigging for it to be successful.

Treatment plants

Systems with treatment plants need to know how to troubleshoot the stability of the chloramines they are producing. The details of dosing to maintain a stable monochloramine residual are given in **'DAM 5—PROCESS MANAGEMENT FOR SYSTEMS USING CHLORAMINES.'**

Part 2. Free-chlorine conversion

Free chlorine conversion may be practiced either in response to Red Flag triggers, or as an annual preventive measure.



Purpose of free chlorine conversion

Free chlorine conversion is an effective action to resolve any nitrification event, but it can also be used as a preventive strategy.

Doing a free chlorine conversion for the first time can cause concern for people because it is new and unknown. These guidelines are offered to minimize the concern which people have and ensure that they can develop the most effective procedures for ridding their distribution of nitrifiers.

Converting to free chlorine is often called "shocking the system," or "burning the system out." These are actually inaccurate descriptions, as the perception is that the chlorine is effectively "killing" the bacteria by attacking it with a strong chlorine residual.

It is true that the free chlorine is killing the nitrifying bacteria, but mainly the way this happens is by STARVATION. When free chlorine is present, there is no ammonia as a food source for the first phase of nitrification starves the AOB; then when the AOB no longer produce nitrite, the NOB starve.

The reason for maintaining a strong free chlorine residual during your conversion is to oxidize the remnants left after the bacteria die, not to kill the nitrifiers directly by disinfection.

Pro: It works!

- **Pro:** It is the only way to starve AOB,
  - Otherwise, bacteria can keep 'blooming' because they have food (ammonia).
    - Ammonia **can't** be present when free chlorine is present.

97

97

Con: It is more work

- Con: It works when you **do it right**.
  - More work is required to determine required chlorine dose (or coordinate with supplier).
  - Valves must be operable.
  - Flushing the free chlorine through the system may require additional labor hours,
    - (also flushing in the monochloramine after the burn).
  - Additional monitoring at the start and end.

98

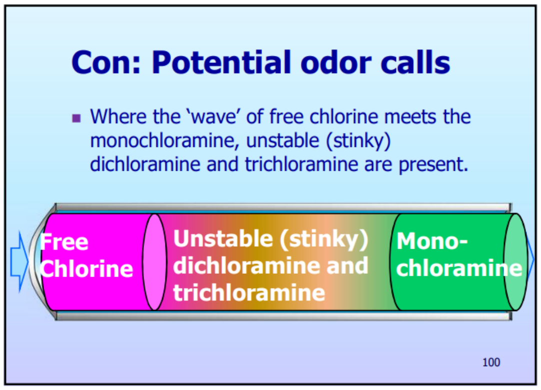
98

Con: Potential odor calls

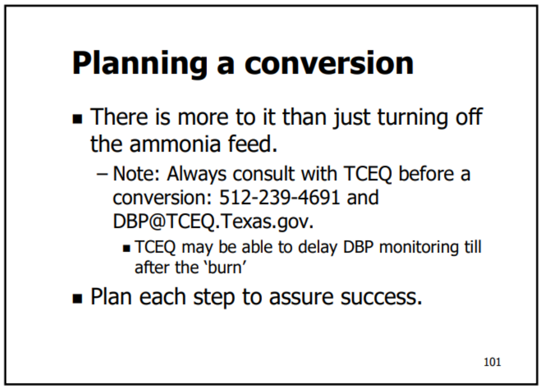
- Con: It works when you **do it right**.
  - If the free chlorine is not flushed through the system quickly, there may be areas with unstable chloramines that smell bad:
    - Dichloramine and trichloramine.

99

99

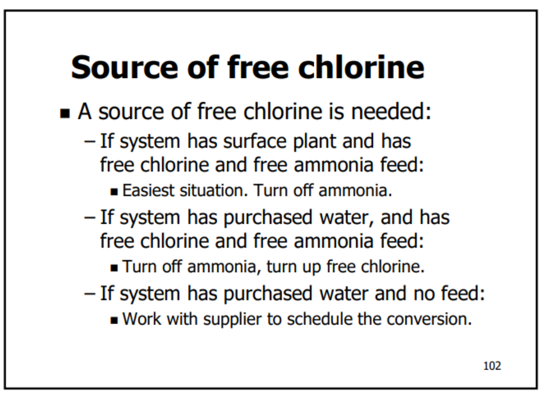


Planning for the free chlorine conversion:



Duration of conversion

You should decide on the duration of the event. TCEQ may approve a delay of DBP sampling up to 30 days. It is recommended that the conversion be scheduled for as long as reasonable.



Pre-conversion adjustments at surface water treatment plants

At the plant

If possible, deep cycle the clearwells at the surface water treatment plant (SWTP) the night before the conversion begins to minimize the volume of water that has to be transitioned to free chlorine. However, care must be taken to ensure that an adequate supply of water is produced to enable flushing without loss of an adequate water supply or distribution system pressure.

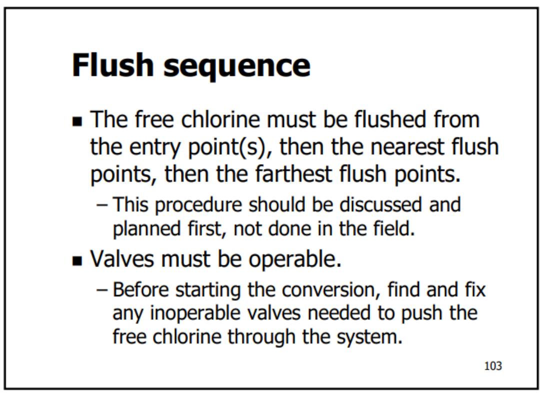
Monitor the chloramine species leaving the treatment plant within a few hours of turning the ammonia feeds off. You want to spend more time establishing a strong free chlorine residual in the distribution system and not at the plant.

1. Consider increasing the monitoring schedules at your plant to minimize the potential for treatment upsets
2. Initially, maintain a 4.0 to 5.0 milligrams per liter (mg/L) free chlorine residual and back down to 3.5 to 4.0 mg/L free chlorine when you detect stronger longer lasting residuals in the problematic areas.
3. Ensure that you change the disinfectant type in the appropriate disinfection zones on pages 4 and 5 of the Surface Water Monitoring Operating Reports (SWMORs).

The treatment plant(s) must produce enough water to satisfy the normal demand, the increased flushing, and supplies for fire safety.

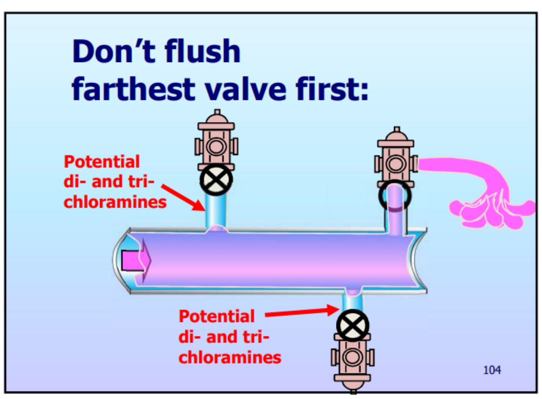
Starting the conversion

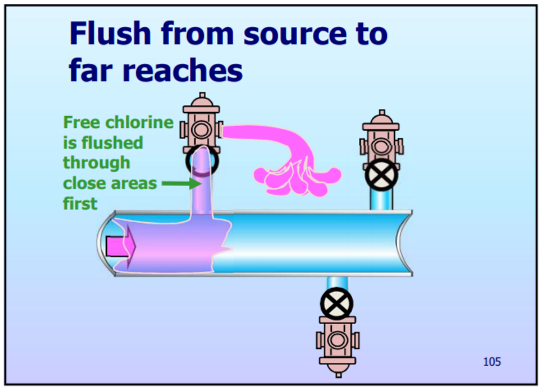
To facilitate distribution of free chlorine to all parts of the distribution system, flushing should be performed in the correct sequence.



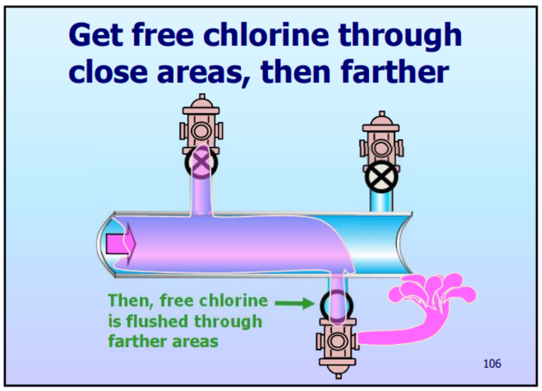
This may require the assistance of additional staff to get the flushing completed as early as possible.

The flushing should get the water moving fast enough to scour out all of the sediment, not just the easily floatable stuff. In order to accomplish that, velocities higher than those established during normal flushing may be needed.

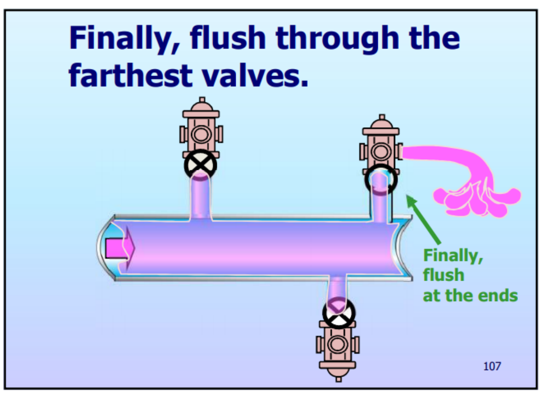




If you flush the water into the smaller lines near the plant first, you won't leave any 'dead' laterals.



106



Pre-planning is needed to target flush groups individually and in the desired order:

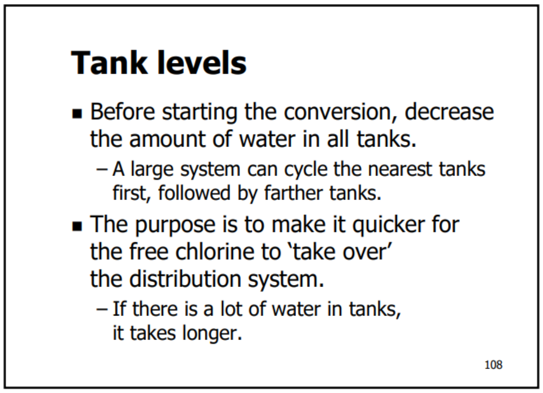
- Larger arterial transfer lines
- Individual neighborhoods
- Dead end mains
- Remote locations

Some considerations include:

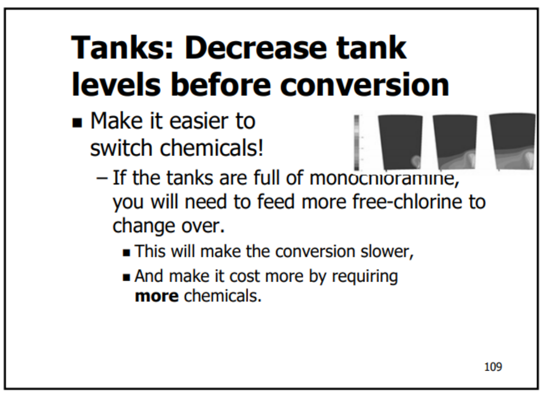
- You may consider performing the heaviest flushing at night to minimize traffic hazards.

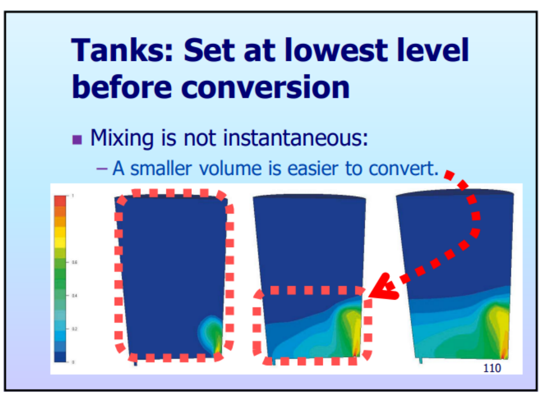
- You may try to focus on using fire hydrants that drain directly into storm drains, bar ditches, or other drainage facilities to minimize flow across thoroughfares.
- You will have to repeat the flushing after the nitrifiers die. Aggressive flushing will be required to remove the remnants of the biofilm.

Tanks

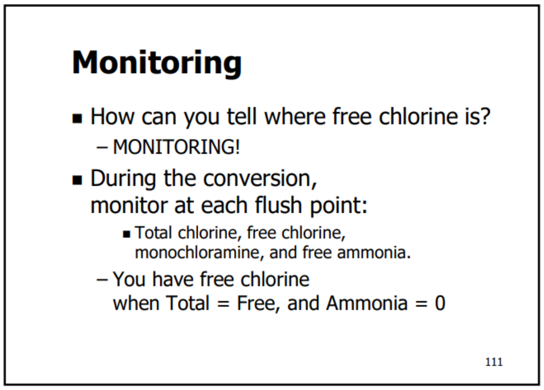


Elevated storage tanks must be deep cycled to expedite pulling the free chlorine water into the tank and into the distribution area they serve.





Monitoring



Increase plant and distribution system monitoring:

- Increased monitoring at the treatment plant (total chlorine and free chlorine residuals) should be performed. Ideally, these two parameters will be very close to each other once the conversion is completed.
- Operators should take free and total residuals throughout the flushing program to determine when the transition to free chlorine (a close match between total chlorine and free chlorine residuals) is complete, and to help determine where the latter part of the flushing efforts should be focused.
- Pressure tests should be performed in areas of heavy flushing to minimize extreme pressure drops or pressures below 35 psi.

NOTE: Be careful collecting coliform samples during the transition periods

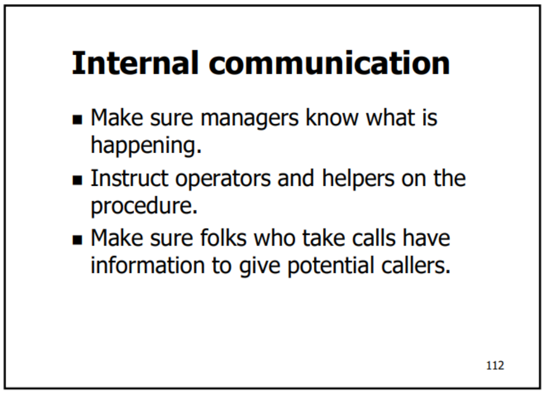
A conversion to free chlorine involves a great deal of work in the distribution system—turning and isolating valves, flushing hydrants, and monitoring water quality. In that process, changes in flow and pressure may stir up sediment resulting in TC+ samples resulting from significant changes in water quality.

Collecting routine coliform samples when the system is in the process of transitioning from free chlorine to chloramines—or back again—may influence results. Avoid collecting bacteriological samples in an area that you have recently flushed very heavily. Give the area some time to settle back down before collecting a sample there.

Communication

Internal communication

Before starting, during the planning process, make sure everyone involved understands their roles and responsibilities, from operators to managers to office staff. Remember, the 3Cs lead to success!

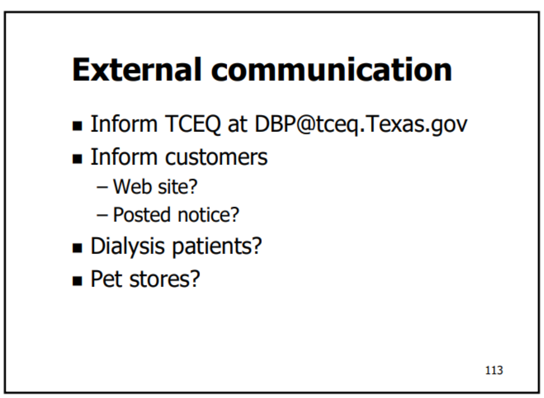


One group that is important is the folks who will be answering phone calls. No matter how well you prepare, you still may receive some customer complaints. Plan to:

- Develop a complaint protocol to ensure customer questions can be managed most effectively and to ensure that any severe problems can be resolved quickly.
- Establish a procedure for dealing with complaints of dirty water, low pressure, etc.
- Develop a frequently asked questions (FAQs) document for the web site and for distribution to customers or handling customer complaints on the phone or in the office.
- Ensure that the employees most likely to field customer complaints are given a copy of the FAQs so that they could better answer customer questions.

Notify TCEQ

You need to let TCEQ know so that they can reschedule disinfection byproduct sampling, if necessary. Both the Drinking Water Quality Team, in Austin, and the Water Section Manager in the Regional office must be notified. Contact the Drinking Water Quality Team at: DBP@tceq.texas.gov or at 512/239-4691 30 days before you plan to convert.



Caveat—Free chlorine conversion is not necessarily a long-term solution

Depending on the extent of nitrifier population of the biofilm, nitrification can reoccur after a free chlorine conversion. It is very useful for areas where the nitrifiers are not too entrenched. If you have areas in which nitrification reoccurs, you should also consider implementing longer-term solutions for the problem areas.

Notifying customers

You should notify receiving systems since they will also be affected by the event. They will have to notify their customers of the conversion, as well.

Notify your customers that you are taking a positive action to make sure that they get the best water possible.

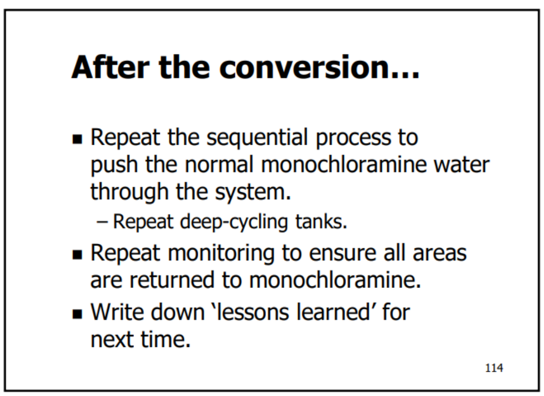
If possible, hold formal meetings with the industrial and medical facilities you serve.

- Some of these facilities (for example those with dialysis units) filter the disinfectant from the water prior to use. These facilities will need time to buy different filters for the free chlorine than those for the monochloramine.
- These customers also need to be made aware if you plan to provide free chlorine at a significantly higher dose, because their filters will not last as long with the higher doses of disinfectant.

By notifying your customers, they will understand the reasons for any change in taste or odor.

Returning to monochloramine

Once your free chlorine conversion is complete and you return to chloramination.



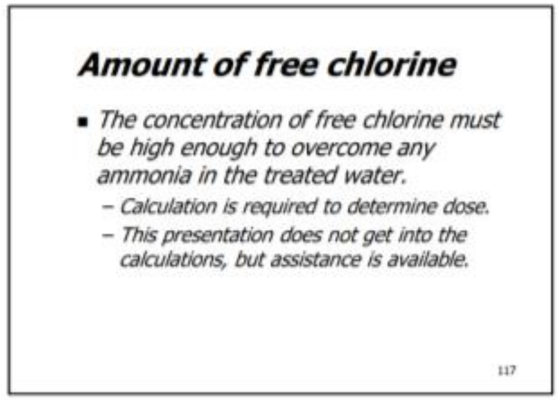
Ensure that you change the disinfectant type in the appropriate disinfection zones on pages 4 and 5 of the Surface Water Monitoring Operating Reports (SWMORs).

Report to your customers when your free chlorine conversion is complete.

- Ensure all customers that filter disinfectant prior to use know that they should go back to their normal filters.
- Ensure that your wholesale customers know to return to monitoring total chlorine instead of free chlorine in the distribution system monitoring.
- Assuming your free chlorine conversion was effective, assure your customer base that the conversion helped ensure that you are able to provide a better potable water with a greater degree of stability.

A less aggressive flushing program can help transition all parts of the distribution system to chloraminated water. Though not as critical as during the free chlorine conversion, it will be necessary to flush to minimize the taste and odor complaints that might accrue as chloraminated water blends with the chlorinated water in the distribution system, elevated storage tanks, and ground storage tanks.

A conversion to free chlorine may be needed each year (or more often), in some systems.



Part 3. Potential long-term actions

In extreme cases, if nitrification is causing frequent problems, you may need to consider engineering solution for long-term solutions. Some examples are listed below.

Part 3. Long-term actions

- In a system that has long-term issues with nitrification, and even periodic free-chlorine conversion does not fix it, longer term solutions may be needed.
  - These longer-term solutions are **outside the scope of this DAM**, but are presented for completeness.
  - Seek professional help to consider changes.

(See Student Guide)

78

If you think that you need to consider an engineering option, you can get additional assistance from TCEQ through the Small Business and Local Government Assistance Division 'EnviroMentors' by calling the small business "hot-line" at 800-447-2827. TCEQ's Plan and Technical Review Section can assist you with questions related to the process of getting approval for engineered solutions at 512-239-4691 or on the web at:

www.tceq.texas.gov/drinkingwater/planrev.html

Disclaimer!
These potential solutions are just examples. Your mileage may vary. Not every system is the same, so a system-specific solution should be identified. Implementation of any engineered long-term solutions is outside the scope of this DAM. You should consult with TCEQ before making changes—written approval may be required, and the TCEQ may place monitoring and other conditions on that approval.

Examples of long-term actions

- Looping mains, eliminating stagnant areas.
- Adding tank mixers, or modifying inlets/outlets
- Changing or adding dosing or injection.
- Free chlorine plus aeration for THM (trihalomethane) removal.
- Etc.

79

Looping mains

● If a PWS identifies nitrification due to dead-end mains (DEMs), it may be appropriate to perform infrastructure replacement in the problem area to manage water age. Consult with TCEQ before making distribution piping changes.

●● Every public water system is required to have a monthly dead-end main flushing program to minimize stagnation of water.

Tank changes

● Tanks can be a source of major water age. In some cases, a PWS may choose to completely eliminate tanks or replace larger tanks with smaller ones. Consult with TCEQ and get approval in writing before removing tanks.

●● Some PWSs have found mixing to be helpful in eliminating chloramine residual loss due to tank stratification. Consult with TCEQ before installing mixing equipment.

● Tanks must always have a compliant disinfectant residual.

● Tanks should be operated with as deep cycling as possible in order to refresh the stored water, and not allow it to stagnate.

Booster disinfection

●● If the size and shape of a distribution system are very challenging, the addition of booster chloramination may be appropriate. Usually, both chlorine and ammonia injection should be at the booster station. However, if the water upstream of the booster contains free ammonia, it is possible to inject chlorine to tie up that free ammonia and form monochloramines. In that case, ammonia injection might not be needed, but TCEQ approval may be needed. Consult with TCEQ and get approval in writing before installing any treatment.

pH adjustment

●● Monochloramine is more stable at higher pH. Nitrifying organisms grow more rapidly at pH 7.5 than at pH 8. Chloramines are more unstable at lower pH. For these reasons, a PWS may choose to adjust pH. If pH adjustment is used, the impact on corrosion control should be considered. Consult with TCEQ and get approval in writing before installing any treatment.

Free chlorine & aeration

● Some groundwater systems with high total organic carbon have used free chlorination followed by aeration to volatilize chloroform to make it possible to meet disinfection byproduct regulations with a free chlorine distribution system residual.

Chlorite feed

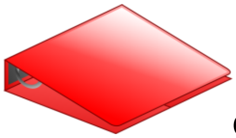
● Research shows that the presence of chlorite (ClO_2-) may slow or stop nitrification from developing. It will *not* necessarily work to stop nitrification that has already started.

Chlorite is a regulated disinfection byproduct of chlorine dioxide. A system considering chlorite feed should be prepared to perform chlorite sampling in distribution, seek approval from the TCEQ, and comply with all conditions that TCEQ puts in place if and when it is approved. Consult with TCEQ and get approval in writing before installing any treatment.

Other solutions?

Research continues on nitrification. Some new methods may be snake oil, but others may turn out to be successful. Use professional development opportunities to learn about new technology.

Assignment: Review PWS's NAP actions



Consider the PWS's own NAP actions.

Determine whether SOPs or instructions exist for each action, or if follow up is needed to develop some SOPs.

Often, taking action requires approval. SOPs telling what actions to take should include how to get approval for an action. Make a note of communication that needs to take place for consideration in the next workshop.

● *Yellow alert actions*

Consider the actions described in this chapter and gather existing SOPs. Review how current actions are started. If existing actions should be initiated based on a yellow trigger event, update the SOPs to reflect that.

Consider actions that you want to initiate in a yellow event that you don't have SOPs for. Make a plan to write the SOPs and instruct operators on their use.

● *Red alarm actions*

Again, consider the actions described in this chapter and gather existing SOPs. Particularly, review the actions that you chose to respond to a yellow flag trigger. Consider whether those actions should also be initiated based on a red trigger event. Update the SOPs to reflect that, or make a plan to do so.

Consider actions that you want to initiate in a yellow event that you don't have SOPs for. Make a plan to write the SOPs and instruct operators on their use.

Chapter 3 Review Questions

(Questions may have MULTIPLE correct answers.)

What are some actions that are used during normal operations to prevent or control nitrification?

1. Flushing
2. Maintaining stable chloramines
3. Answering complaint calls
4. Injecting a nitrite solution

What are steps to take after a Yellow alert?

1. No extra action is needed
2. Flush immediately throughout the system
3. Alert the media and retail customers
4. Verify sample results
5. Take additional samples
6. Identify the affected area

When is a free chlorine conversion a good idea?

1. When nitrification is found
2. When the ammonia feeder breaks down
3. Periodically, as a system maintenance procedure
4. For the two months after DBP samples are collected

Chapter 3 Checklist

Actions checklist:

- Have you chosen the actions that you will take in response to Yellow triggers? Red triggers?
- Have you considered all existing SOPs related to actions?
- Have you planned to update or create any needed SOPs?

Have you noted any approval processes or management notification that needs to occur?Follow up:

If you have set actions for all your yellow and red triggers for all your NAP sites, you are 80% done producing a successful NAP sampling plan.

If you still need to set some actions—make a plan for that and write it down on your follow-up plan.

Next steps

At this stage in the training, you are almost done.
In the next workshop, we will discuss communication strategies.

Chapter 4:
Communication strategies

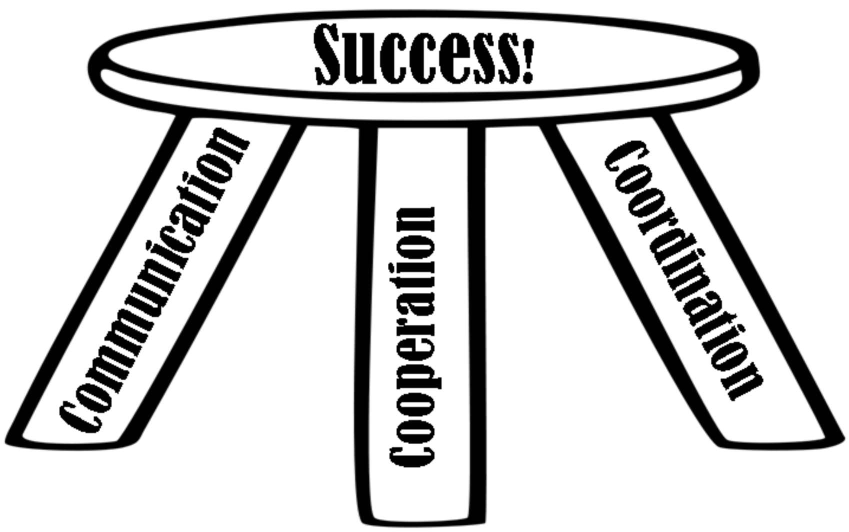
Scope

Before we put the NAP together, let's talk about how to make sure that everyone who has a role in implementing the NAP is aware of that role, and ready to do it. This workshop will use your organization chart and SOPs to discuss who needs to communicate, and how, to make sure the NAP gets implemented.

This workshop builds on the previous chapter, where you developed action SOPs. The actions you need to take may make it necessary to communicate with someone to ask permission, to let someone know what is taking place, or to direct someone to take action.

Everything goes more smoothly with the "3 Cs:"

- Communication,
- Coordination, and
- Cooperation.



Learning goals

The learning goals for this workshop are:

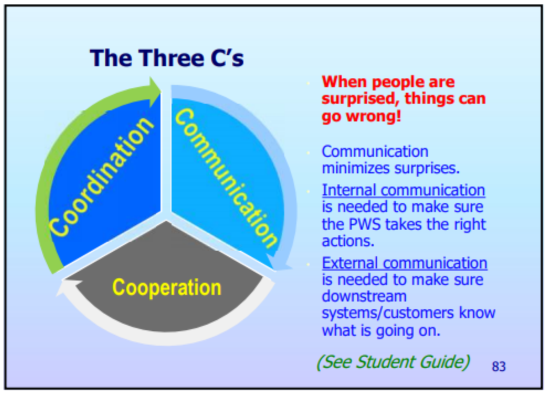
- Understand the importance of SOPs and training for staff performing distribution system tasks;
- Understand the importance of the organizations leadership in providing direction, review, and approval of distribution activities; and
- Understand the manner in which communication with external customers supports the organization.

Materials

Every PWS generally has much of this information in the form of organizational charts, call-lists, and in some SOPs. Your PWS probably has cost limits for what each level can spend—take those into account, also.

General concepts

Communication, cooperation, and coordination (the 3 Cs) make things go much smoother. When people are surprised—things can go wrong. Communication minimizes surprises.



Internal and external communication

Both internal and external communication should be considered.

Internal communication is needed to make sure the PWS takes the right actions. For example, distribution workers need to know the sampling methods and managers need to know what decisions they may need to make when nitrification occurs.

External communication is needed to alert downstream consecutive systems, large users, and retail customers of conditions and changes. For example, if you plan to temporarily convert to free chlorine you must notify the TCEQ, and if you do some form of notice to customers it will cut down the number of complaints.

Decision making

Communication is needed to support the decision making to implement actions required by the NAP.

If the action is minor, it may be okay for the operator to decide to do something. For example, verifying a sample while on-site if the first sample busts a trigger.

However, decisions that cost more money usually require a higher level of management approval. For example, scheduling workers to perform additional flushing and sampling to identify the affected area may need management approval because of the cost of paying for that additional time worked.

Documenting communication in SOPs

Clear instructions and periodic training ensure that workers do their jobs right. Written SOPs are used to give people direction on how to perform tasks consistently and accurately.

SOPs also capture chains of communication. For example, an SOP for how to do nitrite or nitrate sampling might include how to call an outside lab, if samples are not analyzed in the field.

Update reporting SOPs periodically

Over time, the people in your PWS change—people retire, get promoted, or move to Hawaii when they win the Lotto. The SOPs need to list the current people who need to communicate, and include their current contact info.

Communication SOPs and training should be updated to have the right names and numbers. Otherwise, someone will be standing over a main break at midnight listening to the lady say "I'm sorry, this is not a working number" and that is how phones get broke.

If you have SOPs already, make plans to review them to make sure they include directions for communication that are consistent with the NAP, and then to communicate the new instructions to folks doing the work. List those plans on the Follow-up Form if you have not already done so.

"TMI"

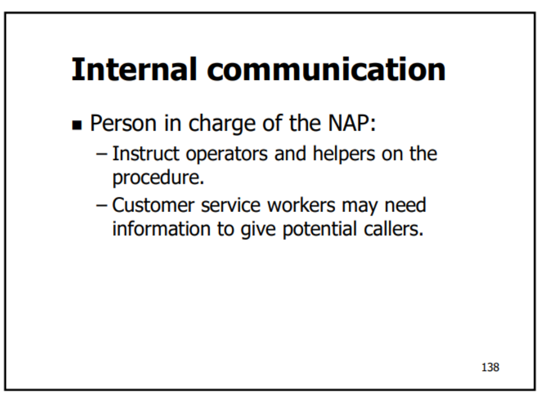
TMI is the acronym for 'too much information.' Effective communication is when the talker gives the listener just the right amount of information. TMI can make communication fail by burying an important point in a bunch of other information so the listener has to look for it like a needle in a hay stack.

Try and make your reports complete enough—but **highlight the important things** somehow. For example, use bold type, or put the details in attachments.

Internal communication

Internal communication includes:

- Instructing workers how to do a task;
- Informing managers of routine operations;
- Informing managers of unusual events or emergencies; and
- Requesting permission to take action.



Requesting permission to take action

It may be simple or difficult to get permission to act, depending on the size and complexity of the PWS. At a small RV Park, the Owner may be responsible for all of the work and also be the one signing all the checks. At a large one, there may be five levels of approval needed to make any purchase over $25.

Consider who is the approver for any of the procedures discussed during this or other workshops.

Instructing workers

SOPs and training are used to instruct workers, which is an important form of communication. When the folks doing the jobs have clear instructions they can do the job are right. Consider any SOPs for the work described in the first five workshops. For example:

- Sampling,
- Field and lab analysis,
- Flushing,
- Managing storage tank levels,
- Any other actions discussed in Workshop 5.

A note about SOPs

Clear instructions and periodic training ensure that workers do their jobs right. Written SOPs are used to give people direction on how to perform somewhat repetitive tasks, for example:

- Collecting samples,
- Analyzing samples, and
- Flushing dead-end mains.

SOPs make sure that everyone does things the same way. Consistency is important for these tasks because if they are done differently, they won't result in consistently accurate results.

Clearly, the SOP needs to capture the current, right way of doing things, or each person will do them differently. That means that SOPs have to be reviewed and changed as the system changes and when they can be improved.

Operators who work in the system a lot often have insights that could make the job more efficient—and save money for the organization. The SOP review process should include a way to capture those ideas.

New employees

New employees need to be given the SOPs. One way that procedures become inconsistent is when a new operator comes on the job and does not get trained. It is easy for them to keep doing things the way they were taught elsewhere. If those ways are better—great—the SOP needs to get updated. But many times there are system-specific reasons that a PWS needs things to be done 'their' way, and early, clear training makes this happen.

Refresher training

Just as new employees need training, every worker benefits from refresher training. Each year, consider whether there are staff who are not familiar with the NAP. You can request a follow up visit from the TCEQ's FMT contractor or perform in-house training.

The best way to make sure the instructions are clear is to write them down and train on them. The best way to make sure the instructions are correct is to update them periodically.

Routine reporting to supervisors

Everyone bosses someone

People at all levels of the organization have to direct the work of others. Clearly, the top-most manager directs his lower-level managers. But even a D-Level operator may be expected to direct important work done by contractors or unlicensed workers. Therefore, clear instructions are needed throughout the entire organization.

Informing managers routinely

Every person has to tell their bosses how it is going—and that is what routine reports are all about. Consider having a way to report how NAP implementation is going routinely, even when it is going well and there is nothing to report. That way, a new manager will know right away that the NAP exists. When things change, they won't have to ask 'What is a NAP?'

Emergency communication

Informing managers in emergencies

A lot of discussion on communication has to do with what happens when everything goes wrong. Managers need to know right away about a small subset of issues. That subset should be well documented.

Do you have up-to-date emergency contact information for key managers? Also double-check the conditions that will trigger calling them in off hours.

Asking for money

Every organization has a different way to approve expenditures. Consider whether your procedures allow you to effectively implement your NAP. If so, make sure the procedures are documented and everyone understands them so that no one makes a mistake. If not, schedule a time to talk with the managers who control the purse strings in order to ensure that you can implement your NAP.

External communication

Your procedures may include communication with:

- Water customers,
- Interconnected PWSs,
- Laboratories, and
- The TCEQ.

Sometimes you have to communicate with these entities by rule—if you already have strong communication pathways, it is a lot easier. You build strong communication pathways by interacting even when there is not a crisis going on.

External communication

- TCEQ
- Customers
  - Web site?
  - Posted notice?
- Dialysis patients?
- Pet stores?

139

The purpose of external communication is different than internal communication. Ideally, internal communication is just what you need to do to ge the job done. External communications ranges the gamut from public relations to boil water notices. The communication connected with the NAP also has that range.

Water customers

Most PWSs have routine ways to communicate with customers, for example:

- Bill stuffers,
- Web postings,
- Social media,
- Newsletters,
- Community message boards, and
- Door hangers.

The method you use depends on the situation. Consider the situations related to a NAP that might cause you to want or need to communicate with your customers. For a loss of chlorine due to nitrification you might want to use advisory door-hangers. For letting people know that you were going to do a routine free chlorine conversion, a web posting or bill stuffer might work.

Consider your existing chain-of-command. In large organizations, there may be people who are always part of the process of getting information to the public—eg "Public Relations" or "Media Information." Ensure that they are correctly referenced in any SOPs related to the NAP which may require interacting with the public—like a temporary conversion to free chlorine. In small organizations, you may need to ask your spouse.

For actions that result in notifying the public, make sure your SOPs are up-to-date.

Interconnected PWSs

Usually, interconnected PWSs have official ways to communicate. Often, managers or representatives of interconnected PWSs are members of an organizational group like a board or council. Also, there is usually ongoing email and telephone communication between managers or lead operators regarding routine operations. Both of these types of communication (and any others) should be taken into consideration.

The most common way that a NAP requires that PWSs communicate is that the TCEQ requires that a PWS notify any PWSs that purchase and redistribute their potable water.

Laboratories

There are routine and emergency situations where you may need to contact a lab. For example, if you are fighting a nitrification event and need nitrite/nitrate sampling on the weekend. You should have the routine and emergency contact information for any labs documented in SOPs.

TCEQ

In some conditions, you must notify the TCEQ.

- You must notify the TCEQ 30 days before doing a temporary free-chlorine conversion.
- If you need to issue a boil water notice, you must notify TCEQ Central Office and Region.

Make sure you have up-to-date contact information for your Regional Office.

The contact information for the TCEQ Central Office public drinking water program is 512-239-4691. Emails may be sent to PDWS@tceq.texas.gov

Chapter 4 Review Questions

(Questions may have MULTIPLE correct answers.)

Who may be key internal stakeholders for a NAP?

1. Distribution operators
2. Contractors that perform repairs
3. Utility superintendent
4. Office staff who take calls
5. Mayor

When is it likely that residential customers will need notification?

1. When additional flushing is performed
2. When a free chlorine conversion is planned
3. When extra samples are collected
4. When a sampling plan is changed

What other communication with external stakeholders may be needed?

1. News media
2. Downstream purchased systems
3. Upstream purchased systems

Chapter 4 Checklist

Go over the NAP actions you listed in Workshop 5. Review what communication strategies are needed to implement each action.

Consider the other SOPs that you discussed for sample collection, analysis, and data review. Review what communication strategies are needed to implement each action.

Consider the SOPs for external communication strategies. If needed, plan to review these with managers who will be key points-of-contact.

Update the communication strategies for all procedures.

Communication strategies checklist:

- Have you considered who inside your organization needs to know about the NAP?
- Have you planned to update or create any needed SOPs to reflect up-to-date names and contact information?
- Are financial approval processes consistent with implementing NAP actions? (For example, can you get overtime for flushing approved?)
  If unknown, have you planned to schedule a meeting with financial staff?
- Do you have procedures for external communication with customers (for example, bill stuffers)?

Follow up:

If you have completed the previous workshops and updated your coordination strategies, you have your NAP. Now, you can go ahead and implement it.

Notes

Chapter 5:
Putting it all together

Scope

The NAP includes:

1. Map of compliance and process management sites,
2. Schedule for sampling,
3. List of Analytical Methods,
4. Goals/baselines and triggers,
5. Actions, and action plans or SOPs.

The first three items were discussed and developed in **"DAM 5: PROCESS MANAGEMENT FOR PUBLIC WATER SYSTEMS (PWSS) USING CHLORAMINES".** The last two items were discussed in the previous chapters. In this chapter, we will put this together in a NAP table.

The NAP table is just a simplified way of listing sample sites; goals/baselines and triggers; and actions to take in response to triggers.

The NAP includes the NAP table and all of the other supporting information

Learning goals

The participants should:

- Be able to gather the information to put in the NAP,
- Be able to complete the NAP template (matrix) for their PWS, and
- Be ready to share the NAP with managers and TCEQ.

Materials

The materials that will be used for this section are:

- Distribution map,
- List of sites and sample schedules,
- LAM,
- NAP matrix template, and
- List of people involved in implementing the NAP through communication, coordination, and cooperation.

NAP matrix template

The template for your NAP table shown below is a way to organize your goals, baselines, triggers, and actions into a single table:

NAP Matrix Template

Chloramine-Effectiveness Sample Suite						
Site	Chemical	Goal	Yellow Flag		Red Flag	
			Trigger	Actions	Trigger	Actions
List Entry Point(s) sites __________	Total chlorine and mono-chloramine	___ mg/L	___ mg/L		___ mg/L	
	Ammonia	___ mg/L	___ mg/L		___ mg/L	
List Average water age sites __________	Total chlorine and mono-chloramine	___ mg/L	___ mg/L		___ mg/L	
	Ammonia	___ mg/L	___ mg/L		___ mg/L	
List High water age sites ___________	Total chlorine and mono-chloramine	___ mg/L	___ mg/L		___ mg/L	
	Ammonia	___ mg/L	___ mg/L		___ mg/L	
Nitrite and nitrate						
Site	Chemical	Baseline	Yellow Flag		Red Flag	
			Trigger	Actions	Trigger	Actions
A system with one source, one entry point will have ONE set of baselines/triggers/actions.						
List each Entry Point(s)	Nitrite	___ mg/L	___ mg/L		___ mg/L	
	Nitrate	___ mg/L	___ mg/L		___ mg/L	
List each Source water(s)	Nitrite	___ mg/L	___ mg/L		___ mg/L	
	Nitrate	___ mg/L	___ mg/L		___ mg/L	
List all points with Blended water (s)	Nitrite	___ mg/L	___ mg/L		___ mg/L	
	Nitrate	___ mg/L	___ mg/L		___ mg/L	

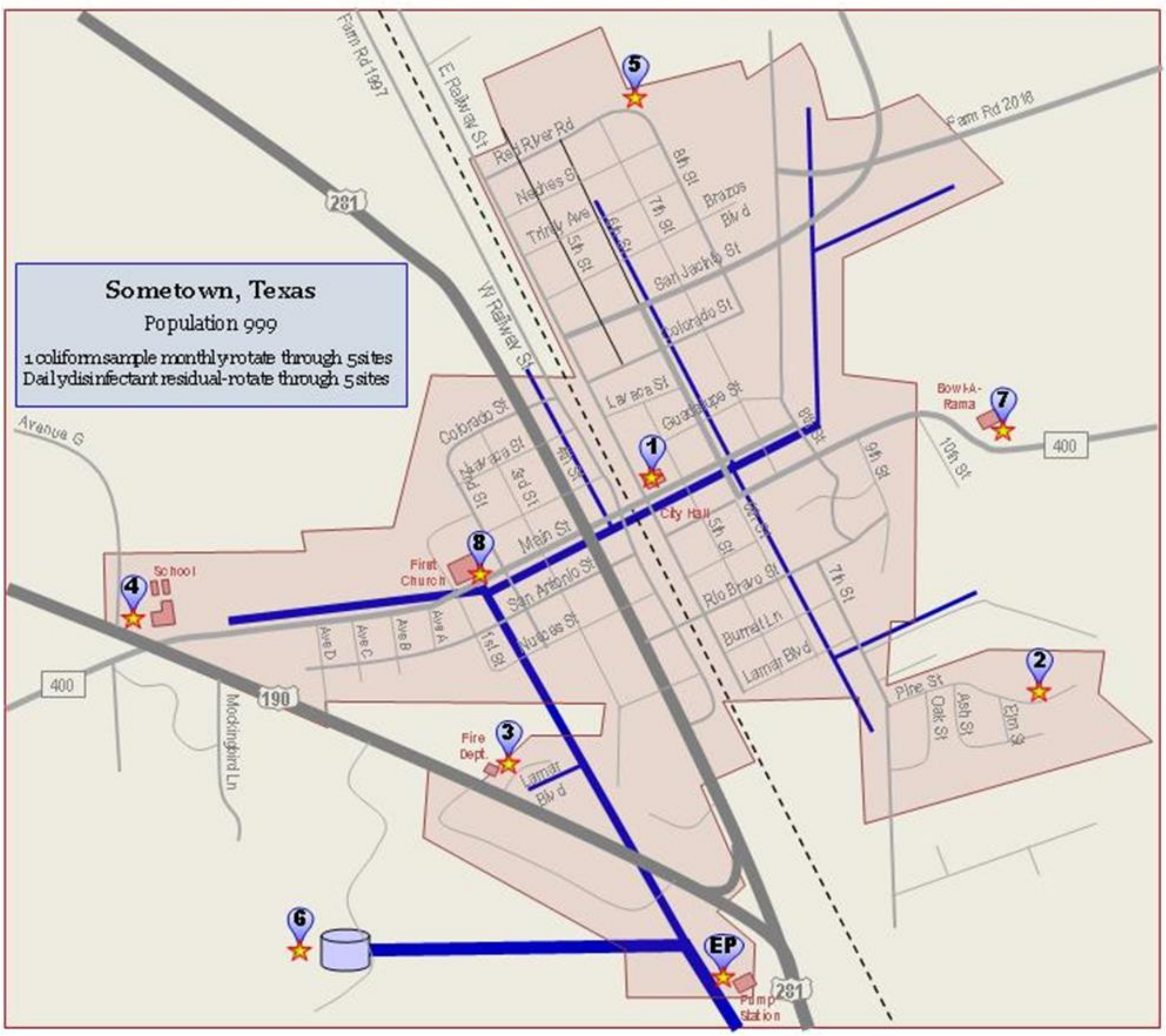
The following example includes a completed NAP matrix for a system with one source and one entry point.

CITY OF SOMETOWN EXAMPLE NAP

The City of Sometown is submitting this NAP to the TCEQ in response to a request from the TCEQ. It includes:

- A map showing sites, sources, storage, etc.;
- A sampling schedule;
- A list of analytical methods (LAM);
- The NAP matrix showing goals/baselines, triggers, and actions; and
- A list of operators/managers with responsibility for the NAP and communication related to the NAP.

Example Map



City of Sometown NAP Map

City of Sometown NAP Sample Schedule

Site #	Address	Type	Comment	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
EP	281 Pump Station	HB	Source	T/M/A, N/N	T/M/A	T/M/A	T/M/A	T/M/A	T	T
1	55 E Railway St	HB	Average		T					
2	935 Pine St	HB	High	T/M/A, N/N						
3	200 W Lamar Blvd	HB	Low			T				
4	800 W Hwy 190	FV	Average				T			
5	700 Red River Rd	HB	High					T		
6	Hill Top Tank	HB	Storage	T	T	T	T	T		
7	10 W Main St	FH	High						T	
8	1164 E CR 400	HB	Average							T

T = Total chlorine—
NOTE: all Total Chlorine samples collected at Compliance Sites must be reported on DLQOR
T/M/A = Total chlorine, monochloramine, and ammonia,
N/N = Nitrite/nitrate

City of Sometown LAM

Analyte	Method[1] (& Analyzer Type)	Accuracy[5]			Calibration Frequency[6]	Calibration Method
pH	Oniom probe	±	0.01	pH unit	Daily	SOP #1
Temperature	W-Mort Meat-O-Meter	±	0.01	C	n/a	n/a
Alkalinity	n/a	±	n/a	mg/L	n/a	n/a
Hardness	n/a	±	n/a	mg/L	n/a	n/a
Disinfectant						
Free Chlorine[2]	Hoch Super Meeter	±	0.01	mg/L	Every 90 days	Per Hoch
Total Chlorine[2]	Hoch Super Meeter	±	0.01	mg/L	Every 90 days	Per Hoch
Free Ammonia (N)	Hoch Super Meeter	±	0.01	mg/L	Every 90 days	Per Hoch
Chlorine Dioxide[3]	n/a	±	n/a	mg/L	n/a	n/a
Nitrification	Field method					
Nitrite	Hoch Super Meeter	±	0.01	mg/L	Every 90 days	
Nitrate	Hoch Super Meeter	±	0.01	mg/L	Every 90 days	
Nitrification	Lab method					
Nitrite and Nitrate	Send to Abba-Dabba-Lab (see Lab Approval form)	See attached			See attached	See attached

Example NAP Matrix with Goals/Baselines, Triggers, and Actions

Total chlorine, monochloramine, and free ammonia goals, triggers, and actions

Site	Chemical	Goal	Yellow Flag		Red Flag	
			Trigger	Actions	Trigger	Actions
EP and Low water age: **EP001 at 281 Pump station, and site #3**	Total	**= 4.0**	**< 3.5**	1) Verify results 2) Check and adjust dose → *Till levels return to normal*	**< 3.0**	1) Verify results Contact supervisor 2) Adjust dose 3) Check source quality → *Till levels return to normal*
	Mono	**= 3.8**	**< 3.3**		**< 2.8**	
	Ammonia	**= 0.15**	**< 0.1** *or* **> 0.2**		**< 0.3** *or* **> 0.5 ***	
Average water age: **Sites #1, #4, and #8**	Total	**= 2.0**	**< 1.5**	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 → *Till levels return to normal*	**< 1.0**	1) Verify results Contact supervisor 2) Measure nitrite and nitrate 3) Adjust dose 4) Identify affected area (check upstream and downstream) 5) Flush area 6) Flush dead ends 7) Convert to **Free Chlorine** → *Till levels return to normal*
	Mono	**= 1.8**	**< 1.3**		**< 0.8**	
	Ammonia	**= 0.3**	**< 0.2** *or* **> 0.4**		**< 0.1** *or* **> 0.5 ***	
High water age: **Sites #2, #5, and #7**	Total	**= 1.5**	**< 1.0**		**< 0.6 ****	
	Mono	**= 1.3**	**< 0.8**		**< 0.4**	
	Ammonia	**= 0.4**	**< 0.3** *or* **> 0.5 ***		**< 0.25** *or* **> 0.75 ***	

* If free ammonia reads "0.5" the ammonia concentration is above the limit of the instrument. Do a 1:1 dilution of sample water with Distilled water, analyze, and multiply the result by 2.

** Less than 0.5 mg/L Total is below the minimum required residual level and should be reported immediately to supervisor.

Nitrite and nitrate baselines, triggers, and actions

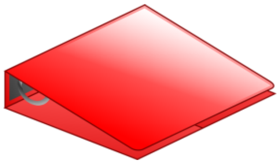
Site	Chem.	Base-line	Yellow Flag		Red Flag	
			Trigger	Actions	Trigger	Actions
ALL SITES	Nitrite	**= 0.025**	**< 0.02** *or* **> 0.03**	1) Verify results 2) Identify source changes IF confirmed- modify baseline 3) Identify area, 4) Flush area → *Till levels return to normal*	**< 0.01** *or* **> 0.04**	1) Verify results 2) Identify affected area 3) Flush 4) Perform free chlorine burn → *Till levels return to normal*
	Nitrate	**= 1.5**	**> 1.7**		**> 2.0**	

Communication

Summary of managers and staff

Position	Name	Office	Emergency	Note
City Manager:	Bob D. Bauss	(956) 239-1234 BobBauss@ourcity.com	(341) 555-1212 bobbydb@aol.com	Do not contact. Micky or Shirley will contact if needed.
City Sec'y	Shirley Ujeste	(956) 239-1234 CitySec@ourcity.com	(512) 837-5309	Contact any time at all 24/7.
Utility Director	Micky Martinez	(956) 239-1235 MickyM@ourcity.com	(512) 123-9999 Micky@aol.com	Contact immediately if emergency situation occurs and you can't reach Pat.
Chief Operator	'Pat' Patel	(956) 239-1236 ChiefOp@ourcity.com	Mobile (608) 123-1234 Pager (956) 432-4321	Contact any time at all. **Contact when triggers are triggered.**
City Sec.	Ann Aliticcal	(800) 512-6419 Aliticcal Labs	(800) 512-6419	Contact for sample results

Assignment: Review this PWS's NAP



Go through the PWS's NAP to see if it is complete and accurate.

Consider whether it includes:

1. Map of compliance and process management sites,
2. Schedule for sampling,
3. List of Analytical Methods,
4. Goals/baselines and triggers,
5. Actions, and action plans or SOPs.

Chapter 5 Checklist

(NOTE: This Chapter does not have review questions.)

Go through the checklist and note incomplete items on your Plan of Action.

Wrapping-it-up checklist:

- Do you know the five parts of the NAP?
- Do you have a complete, readable, printable map of all pipes, pressure planes?
    - Do you have a map and list of your sample sites for total chlorine, monochloramine, free ammonia (as nitrogen), nitrite, and nitrate?
- Do you have a sample schedule?
- Do you have a List of Analytical Methods?
- Do you have procedures for communicating internally and externally?
- Do you have a completed NAP matrix with goals/baselines and triggers for total chlorine, monochloramine, free ammonia (as nitrogen), nitrite, and nitrate?

Follow up:

If you have completed the previous workshops and updated your coordination strategies, you have your NAP.

Now, you can go ahead and implement it …

Congratulations!

If not, list your incomplete items on your To-Do List and git 'er done!

Appendix 1: Flushing

Flushing pipes is a critical, though boring and routine, action to keep distribution water clean and safe. If water sits in one place too long, it loses its disinfectant residual and bacteria can grow.

Scope

This appendix is intended to provide general guidance in revising or developing a dead-end main (DEM) flushing standard operating procedure (SOP).

Documents and data

PWSs are required to maintain records of monthly dead-end flushing.

PWSs are required to have a strategy to avoid having dead-ends in the system, for example by requiring developers to 'loop' lines.

More sophisticated PWSs will have SOPs and forms to maintain this data.

Resources

There are resources available to learn more about flushing.

EPA

"Effects of Water Age on Distribution System Water Quality"

www.epa.gov/sites/production/files/2015-09/documents/2007_05_18_disinfection_tcr_whitepaper_tcr_waterdistribution.pdf

AWWA

Distribution System Operations and the Impacts on Water Quality (Flushing Program) Module 7

www.hwea.org/wp-content/uploads/2015/07/Module-7-Final-AWWA-Workshop.pdf

AWWA Partnership for Safe Water: Distribution System Optimization Program

www.awwa.org/Portals/0/files/resources/water%20utility%20management/partnership%20safe%20water/files/Distribution%20Example%20SA%20Report.pdf

Flushing programs

Flushing is an important activity to keep lines clean and fresh—not stagnant.

Dead-end main (DEM) flushing

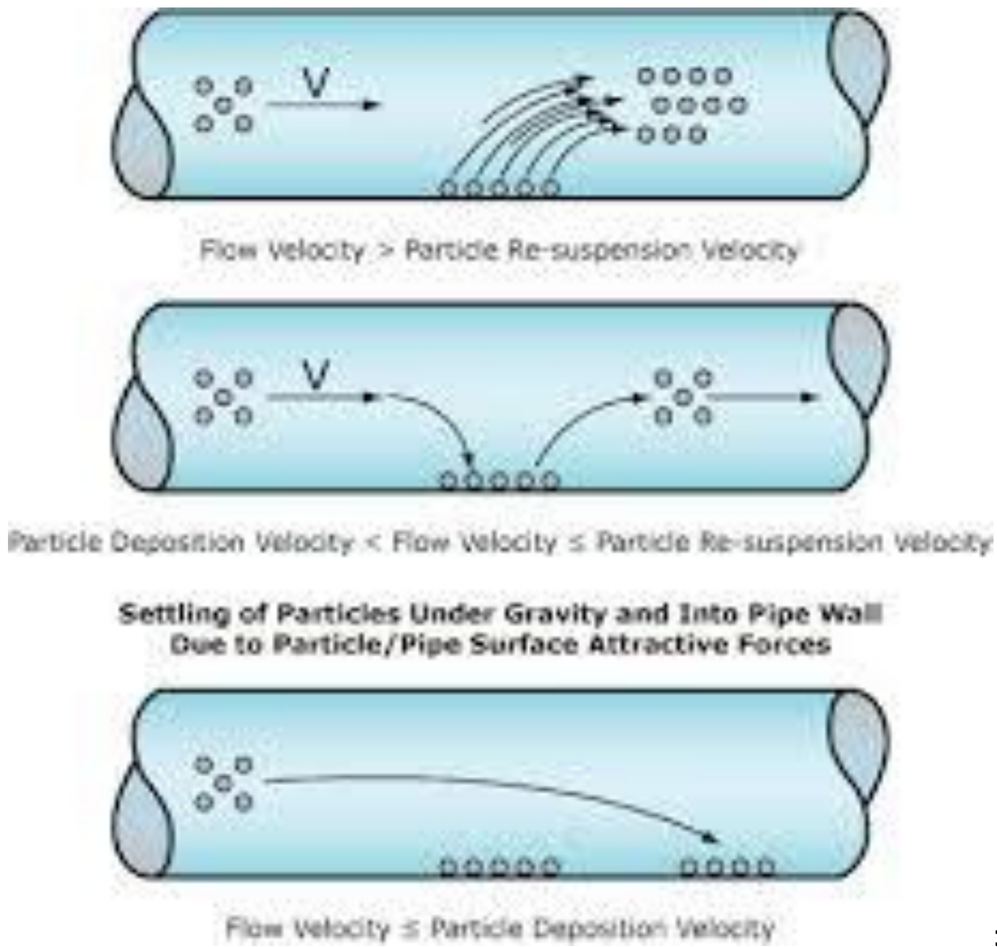
Most PWSs are familiar with the required monthly dead-end main (DEM) flushing. DEM flushing is intended to remove sediment and stagnant water. Generally, this is accomplished by slowly opening fire hydrants or flush valves at the end of mains.

DEMs may be large, but they also may be small, for example in non-looped cul de sacs. Depending on usage, DEMs may need more or less flushing.

Best practice is to measure the disinfectant residual and ensure that a level over the minimum is achieved before ceasing to flush.

Unidirectional flushing (UDF)

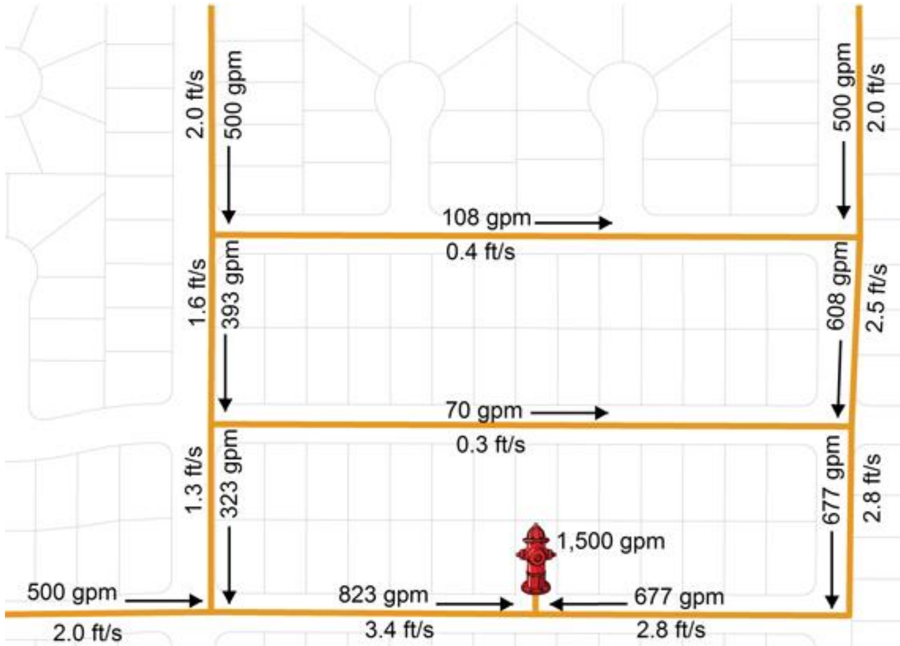
Unidirectional flushing (UDF) is a way to flush any area of distribution to remove sediment. In order to remove settled material, the velocity of the water has to be fast enough to pick up the particles—as shown in the following figure. The velocity needed is over 5 feet per second (fps).



:

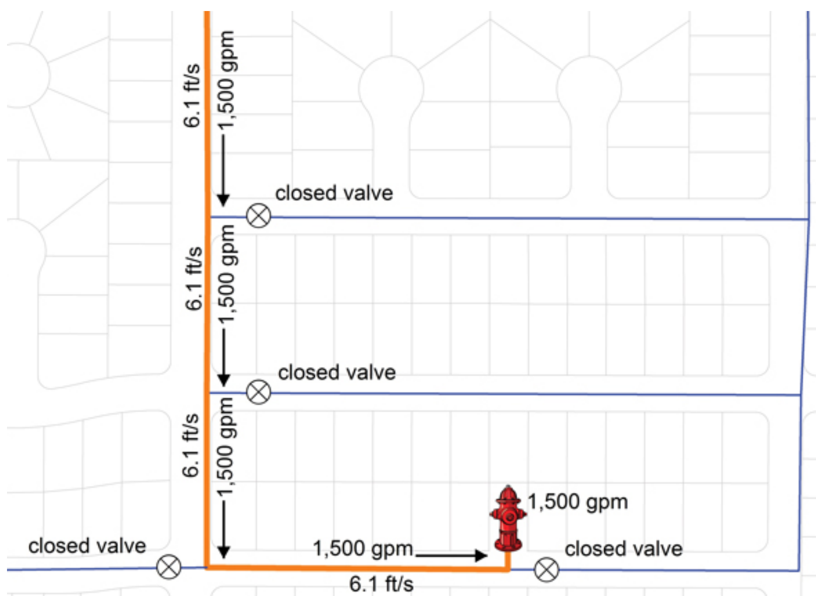
Settling and resuspension in distribution pipes

In order to achieve the velocity of 5 fps or more, the area to be flushed must be identified and managed to make the water flow 'unidirectionally.' In normal flushing, a hydrant is just opened, and water is allowed to flow through the entire area, as shown in the figure below.



Non-UDF flushing, where water is allowed to flow freely

When UDF is practiced, valves must be managed to force water into a pathway that makes it go faster than normal, as shown in the following figure.



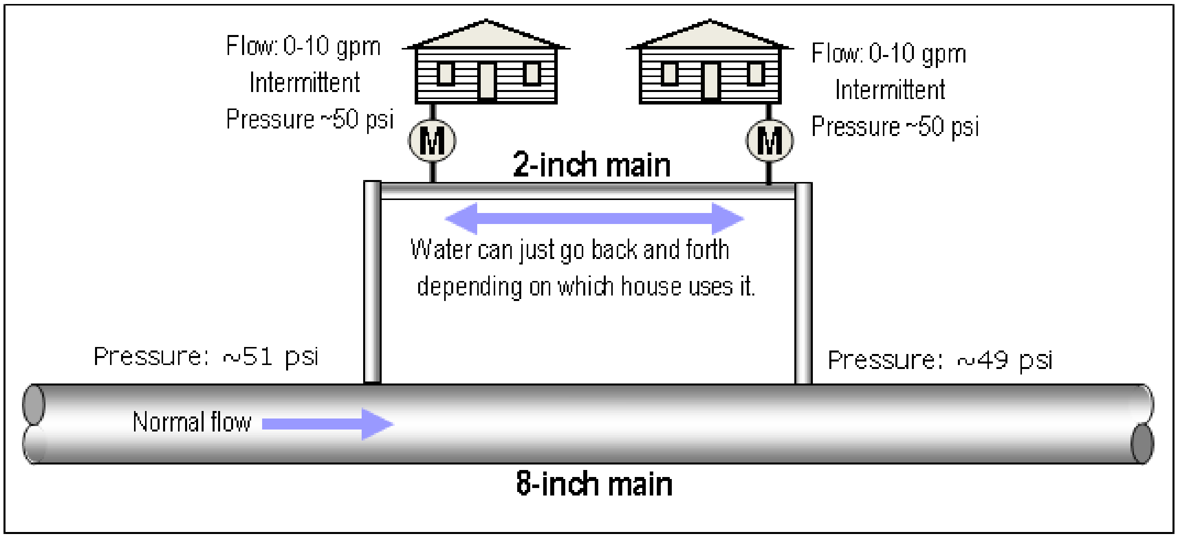
UDF flushing, where water is forced to flow rapidly, in a single path

Clearly, the valves must be cycled so that each pipe gets the single flow, sequentially.

Hydraulic DEMs

Hydraulic DEMs are locations where water can become stagnant, even though there may be no physical DEM.

For example, the following figure shows a situation where two houses are on a small 'looped' lateral served by a larger transmission main. There is not a large amount of flow, and the pressure at each end of the loop is similar—during low use times in the system, the pressure will be equivalent at the ends of the loop. Therefore, the main driving force for flow will be usage from the two houses: when the right-hand house uses water, the lateral will flow westward, when the left-hand house uses water, the lateral will flow eastward. This is called a hydraulic dead end—a place where water can become stagnant even though there is no hydraulic dead end (no 'end' of a pipe).



Hydraulic dead end

Hydraulic dead-ends also are common when a valve that should be open is closed, partially closed, or fouled.

Details of DEM Flushing

1. Why—Purpose of monthly DEM flushing

The purpose of monthly DEM flushing is to remove stagnant water from pipes, bring in fresh water with a strong disinfectant residual, and reduce biological growth in the distribution system.

Stagnant water in pipes allows bacterial regrowth and can allow the persistence of viruses and protozoan cysts. Stagnation in potable water can also cause taste, odor, and color problems. Therefore, disinfectant residual monitoring is an integral part of the DEM flushing process.

DEM flushing is different than flushing before taking a sample

Flushing to bring fresh water to a location is different than flushing to take a sample. When you take a sample, you just flush enough water to clear the old water out of the sample line and bring water from the main to the tap.

When sampling, a little water is flushed; during DEM flushing a lot of water is flushed. During sampling, flushing may end before a strong residual is measured; during DEM flushing, a strong residual should be present before you stop flushing.

Standard operating procedures (SOPs) for DEM flushing

Standard operating procedure (SOP),

By establishing a formal DEM flushing SOP, a PWS can ensure that water used for flushing accomplishes its goal without wasting water.

A DEM flushing SOP should include:

1. **WHERE:** A list of all DEMs, including the address (or intersection), the flush-valve type, and the estimated flow;
2. **WHEN:** A schedule for flushing all DEMs monthly (and if triggered);
3. **HOW:** Instructions for how to flush, particularly closing valves slowly;
4. **WHAT:** Instructions for what to measure, including the data sheet for writing down
    - When and where DEMs were flushed,
    - How much water was flushed,
    - The residual before and after flushing; and
    - Whether the levels triggered actions like more flushing or contacting a supervisor; and
5. **WHO:** Who should be called if the residual (or anything else) is a problem, who maintains the file of DEM flushing data sheets, and who will revise the SOP when needed.

Like any SOP, a DEM flushing SOP is a 'living' document. It should be reviewed and updated as the system changes.

2. Where—DEM locations

A PWS should have a list and map of all DEMs, including:

- the address (or intersection),
- the flush-valve type, and
- the estimated flow;

DEMs exist wherever a pipe is at the end of the distribution system. The TCEQ rules do not set any limit on pipe size for DEMs. Even a 1-inch pipe can be a DEM.

For many or most DEMs, a valve or hydrant may be available for flushing. If not, it may be necessary to identify or add a mechanism to flush the DEMs where no hydrant is available. The DEM flushing SOP must include a list and map of all DEMs in the system regardless of the size or type of valve.

Pipes less than 2-inch-diameter may end in a hose bibb

The TCEQ operation rules [§290.44(d)(6)] state that pipes less than 2-inch diameter that end in a customer service do not have to be equipped with a flush valve. **All DEMs ≥2" must have a flush valve.** If the DEM is at a service connection, the flush valve may be a hose bibb on a house or business.

However, if frequent flushing is needed, the PWS may decide to install a valve at small-diameter DEMs to avoid any issues regarding use of metered water, or destruction of lawns.

Long-term changes

The TCEQ's design rules in §290.44(d)(6) require that systems have a plan for minimizing DEMs as changes are made to the system. When the system makes changes to loop DEMs in order to eliminate them, the DEM flushing SOP must be updated. When expansion occurs, and additional DEMs are added, the DEM flushing SOP must be updated to reflect these changes, too.

As part of an asset management program, hydraulic dead-end mains can also be corrected.

3. When—Monthly and for process management

The TCEQ rules require that every DEM be flushed monthly.

More frequent flushing may be needed

The TCEQ rules are regulatory minimums. For good operation, in some cases, more frequent flushing may be needed. The purpose of DEM flushing is to clear the lines of sediment and provide a good disinfectant level. If very dirty water or low residuals are present, more frequent flushing may be needed.

Most adequately-operated PWSs set internal goals based on their expert knowledge of their system. These internal goals take into account the rate at which disinfectant decays, impacts from temperature, and seasonal variation. The goals are generally based on the minimum regulatory requirement plus a safety factor.

The reason a safety factor is needed is because if the minimum were the goal, any little problem could cause a non-compliant residual.

Particularly in the case of PWSs that use chloramines, PWSs should document the residual levels that will result in more frequent flushing.

Example

For example, if the pre-flush level is zero, and after five minutes of flushing the total chlorine level at a system using chloramines is only 0.6 mg/L; this DEM should probably be visited every two weeks.

(Note: the minimum regulatory level for total chlorine at a PWS using chloramines is 0.5 mg/L)

PWS-specific schedules ("exceptions")

Less frequent sampling is a violation, unless approved by the TCEQ in a written response to a PWS's exception request. In an exception approval, the TCEQ will set conditions that the residual must be **measured** at every DEM monthly—but not necessarily flushed. Under the PWS-specific approval, if the residual is over a certain level, then the PWS is allowed to postpone flushing. However, if the level is under that level, the PWS must flush more frequently. If you are interested in exceptions, contact the TCEQ's Technical Review and Oversight Team.

4. How—Flushing procedures

The DEM flushing SOP needs to have detailed flushing instructions for operators to follow. These instructions and proper training of operators flushing DEMs will reduce the volume of water used for flushing DEMs.

Equipment for flushing

In order to flush correctly, an operator should have the right tools handy. DEMs may have different types of flush points:

- Fire hydrants,
- Flush valves,
- Service connections (not as desirable).

Depending on the type and location of a DEM, some equipment needed may include:

- Flush valve or fire hydrant valve wrenches;
- Keys to lock(s);
- A watch to time how long the DEM is flushed;
- Calibrated/verified field instrument for measuring disinfectant (and other) levels, with the right sample containers and reagents;
- Flow measuring device (if there is no estimated flow rate for the DEM)
- Any other equipment needed.

Close (and open) valves slowly; open completely

Especially for large valves—like fire hydrants—if you close the valve quickly, there is a risk of water hammer. Water hammer can cause intrusion of groundwater and damage pipes.

Fire hydrants

If staff from the fire department help with hydrant maintenance or flushing, they should be educated regarding this potential risk. The valve should be completely opened at some point during flushing. This helps prevent debris from lodging in the hydrant valve seal when the hydrant is closed.

Also note, for systems with fire protection, not every hydrant is a DEM. Flush valves that look like hydrants, but are not available for fire flow should be painted black as a best practice (and by requirement for some utilities).

Large systems may include color coding for flush valves in hydrant painting schemes.

Valve maintenance

Open valves slowly. If valves have not been maintained, a valve can be damaged during the opening process. The valve should be replaced. A valve maintenance program should be implemented. Generally, a non-working valve should not be replaced with straight pipe and paved over.

Measure or estimate flow rate for each DEM

One purpose for optimizing the DEM flushing SOP is to conserve treated water. In order to control water loss, the amount flushed must be measured or accurately estimated.

At valves that produce a relatively small amount of water, like ~20 gallons per minute (GPM), the flow can be measured and documented using a 'bucket test.' For example, in the case of a valve that can produce 20 gpm, it would fill up a 5 gallon bucket in 15 seconds.

At valves that produce a lot of water—like hydrants—it may be necessary to evaluate the flow using a calibrated flow meter. If the PWS does not have one, it may be possible to borrow one from a neighboring PWS.

After measuring the flow rate for each DEM, that should be documented on the list of DEMs, and on the data sheets.

Other considerations:

Care should be taken to avoid causing environmental or customer issues. Usually water is flushed into a gutter or ditch. However, damage to property, lakes, and streams should be avoided.

Avoid damage to property

It is recommended that a diffuser be used when flushing hydrants. The purpose of the diffuser is to keep the water from causing erosion. Additionally, some diffusers are able to add a chemical (such as sodium sulfite) to remove the chlorine or chloramine.

Water should not be flushed onto a homeowner's lawn without permission of the homeowner. However, it is very beneficial if a stock tank or water feature can be used to collect the flushed water for a beneficial purpose.

Avoid letting disinfectant enter lakes and streams

Precautions should be in place to avoid allowing water with a disinfectant residual to flow into lakes or streams. The disinfectant may kill fish, which is undesirable.

5. What—What to measure and record for DEM flushing

A good SOP contains clear instructions for flushing; documenting the flushing is important because "if it is not documented, it is not done."

Data collection and recording a big part of an SOP. A data-sheet is part of that. If the data sheet is good, it will make it easy for operators to do the job right—it will lead them through the right steps.

General data requirements, regardless of disinfectant

The flushing data sheet should include:

- Operator's name (or ID, or initials)
- Address of location flushed (or DEM ID for large PWSs),
- Date flushed,
- Time flushing started,

- Appearance of water at start of flushing,
- Residual disinfectant at start flushing,
- Time flushing ended,
- Residual at the end of flushing,
- How much water was flushed (this should be estimated accurately),

In order to use the least water, while maintaining adequate disinfection, a PWS must document the amount of water used for flushing. Additionally, in order to control the flushing volume, the PWS must record the disinfectant residual.

Operators should be instructed to collect flushing data on a data sheet, and all data sheets should be gathered and retained in a central location.

Free Chlorine Monitoring Parameters

For a system that uses free chlorine, the primary monitoring parameter is the free chlorine residual. The other items that should be considered are taste, odor, sediment, and water color.

Example of a DEM Flushing Data Sheet
for When Using Free Chlorine as a Disinfectant

Year ________	City of _______					Operator initials	
Month __________	**(Target Free Chlorine = _____ mg/L)**					______________________	
Location/ Appearance at start of flushing	**Start**			**Finish**			
	Date	Time	Free Cl_2 Residual (mg/L)	Time	Flush Duration (mins.)	Free Cl_2 Residual (mg/L)	Volume of water flushed (gals.)
Example: 12 Oak St / Cloudy	*1/1/11*	*3:10*	*0.05*	*3:20*	*10 min*	*0.83*	*100*

Chloramines ("Total Chlorine") Monitoring Parameters

Chloramine monitoring is more complex than free chlorine monitoring. For a system that uses chloramines, their disinfectant monitoring is described in their Nitrification Action Plan (NAP). DEM flushing points may be included in the NAP. In fact, a chloraminating system can optimize their NAP monitoring by using some DEMs as NAP sampling points.

NAP Triggers

Chloraminating systems are required to monitor total chlorine daily or weekly, at sites representing the distribution system. In addition, representative sampling must be performed at sites representing low, medium, and high water age in each pressure plane for monochloramine and free ammonia along with the total measurement.

In addition, nitrification indicators like nitrite, nitrate, or pH may also be sampled.

An example data sheet for a PWS using chloramines is shown below.

Example of a DEM Flushing Data Sheet
for When Using Monochloramine as a Disinfectant

PWS Name: ______ Operator initials: _____

	Yellow-flag triggers			Red-flag triggers		
	Total *	Mono*	NH4*	Total *	Mono*	NH4*
Average water age						
High water age:						

* If post 5-minute flush level is less than Total or Mono Yellow or Red flag Triggers, take actions listed in NAP.

		Pre-flush				Post-flush				Comments	
Location	Date	Time	Total	Mono	Ammo.	Time	Total	Mono	NH4	Volume flushed	Pre-flush appearance

6. Who—The 3 Cs: Communication, Coordination, and Cooperation

Every SOP is a tool for 2-way communication:

- It is a way for supervisors to communicate to operators what should be done, AND
- It is a way for operators to communicate to supervisors that the job was done right.

Both managers and operators should recognize the importance of SOPs and make sure the SOPs are accurate and up-to-date.

- Managers should have an annual time when they review SOPs and check in with technical staff to see if updates are needed.
- Operators should let management know when procedures need to change, so that SOPs can be updated.

Example: New field instrument

A PWS replaced their pocket residual analyzer with a new chem-key type. Technical staff reviewed the SOP and realized that they had not been doing required sample dilutions, so deionized water was purchased and the SOP was changed to make sure that operators made 1:1 dilutions when the residual made the instrument flash *0.55*.

The technical staff notified management of these changes and the Manager made sure that changes were made to the PWS's Monitoring Plan and shared it with operators.

Especially at large PWSs, all operators should get refresher training periodically and whenever the SOP is changed.

Example SOP for DEM Flushing

The following example is for a medium size system.

Example of Flushing SOP for Smallville, Texas

System description:

Municipality; 1,234 population;
one pressure plane; one well, and one elevated-storage tank (EST).

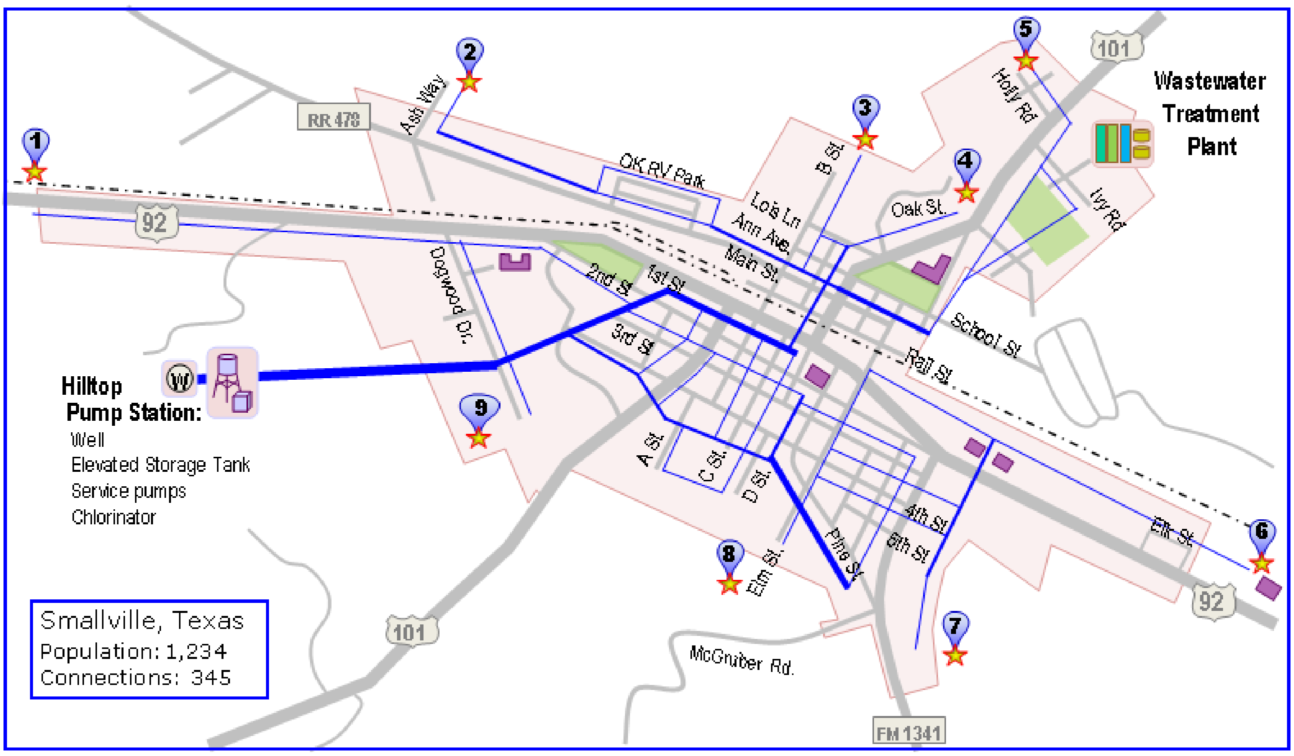
Total chlorine (monochloramine) is used for disinfection.

Rule overview:

Monthly flushing at all dead-end mains (DEMs).

Two (2) coliform samples monthly, rotating through at least five (5) sites.

Daily total-chlorine residual samples, rotating through at least 5 compliance sites (NOT the same as the DEM sites, which are just for process management).



City of Smallville DEM Flushing SOP

Purpose

The purpose of this SOP is to make sure that distribution water is safe, not stagnant, and that a good residual is maintained throughout the entire City.

This SOP should ensure that residuals less than the TCEQ regulatory minimum of 0.5 mg/L total chlorine never occur. Therefore, the City sets a goal to have **0.8 mg/L** total chlorine throughout the system.

Schedule

- FIRST FRIDAY of Month:
    - Flush the NORTH side: Sites 1, 2, 3, 4, 5.
- SECOND FRIDAY of Month:
    - Flush the SOUTH side: Sites: 6, 7, 8, 9
- THIRD FRIDAY:
    - Flush at Macgruber's (Site 7)
        - Macgrubers must be flushed AT LEAST every 3 weeks, more in the fall and winter.
- SITE notes:
    - SITES 2 & 6:
      Although not rated for fire protection, the two HYDRANTS must be completely opened, then closed SLOWLY to avoid damaging the hydrant or pipes.
    - SITE 7:
      Macgrubers must be flushed AT LEAST 20 minutes,
      AND until the residual reaches 0.8 mg/L Free Chlorine.

How to flush and collect data:

(Put the DEM Data Sheet clipboard on the hook in the office when not in use.)

BEFORE FLUSHING, RECORD on the DEM Flushing Data Sheet:

1. The time the DEM flushing started,
2. What the water looked (and smelled) like before flushing,
3. The disinfectant residual before flushing.

FLUSH

4. Open the valve or bibb completely.
5. Flush for 5 minutes, except at Macgrubers' flush for 20 minutes.
6. **Slowly** close the valve.

AFTER FLUSHING, RECORD on the DEM Flushing Data Sheet:

7. Take the post-flush residual and record it.
8. Record the time when flushing stopped.
9. Calculate and record the amount of water used for flushing (see table).

COMPLAINT FLUSHING:

Use the DEM Flushing Data Sheet to record complaint-response flushing. Write in the address and whether you talked to a customer.

If you flush for a complaint from a field-contact, make sure you tell the secretary so he can record it in the Complaint Records.

Call the Superintendent with issues:

If the residual after normal flushing is less than 0.8 mg/L, call the Superintendent at 123-456-7890. If you can't reach her, flush for an additional 10 minutes, call again, record the residual, leave a message.

Flushing locations:

The City has nine (9) DEM locations, listed in the following table.

Smallville, TX DEM Location List

DEM #	DEM Address/ Location	Valve type	Size of Main (inch)	Size of Lateral (inch)	Length of Lateral (feet)	Flush rate (gpm)	Volume flushed in 5 minutes (gallons)
1	Hwy 92 “Gas’n’Git”	FV (Flush valve)	4	1	50	250	1250
2	250 Ash Way	H (Hydrant)	4	2	10	1000	5000
3	707 B St (Smiths)	HB (Hose bibb)	2	0.75	150	5	25
4	616 Oak St	FV (Flush valve)	2	2	500	50	250
5	525 Holly Rd	FV (Flush valve)	2	2	50	50	250
6	VFD 1600 2nd St	H (Hydrant)	4	2	50	1000	5000
7	Macgruber tank	HB (Hose bibb)	1.5	1	1000	10	50
8	804 Elm St	FV (Flush valve)	2	2	5	50	250
9	963 Dogwood Dr	FV (Flush valve)	2	1	50	20	100

DEM Flushing Data Sheet:

Record routine monthly flushing data on the rows provided.

Record other flushing events on the rows provided—note address, etc.

City of Smallville DEM Flushing DATA SHEET

#	Address/Location	Date	Time start	Appearance at start*	Total Chlorine Residual at START	Time end	Total Chlorine Residual at END	Water used
1	Hwy 92 "Gas'n'Git"							
2	250 Ash Way							
3	707 B St (Smiths)							
4	616 Oak St							
5	525 Holly Rd							
6	VFD 1600 2nd St							
7	Macgruber tank							
8	804 Elm St							
9	963 Dogwood Dr							
Flushing at other locations:								

* Appearance **after** flushing should always be "CLEAR." If you can't flush till clear, contact supervisor

Quality Assurance / Quality Control (QA/QC) Documentation

Operators must sign and date that they have read and understood this SOP, and will follow it to the best of their ability:

Name ____________________________Date ___________________

DAM 8 Attachment 2a:
Pre-Test

Instructions: The Pre- and Post-Tests are intended to help you evaluate your learning. All staff who participate in this training event should complete this Post-Test. Answer all questions to the best of your ability. After the Post-Test is done, the Instructor will go over the correct answers.

Training location: ______________________________

Position: ○ Operator ○ Administrator ○ Other

<u>Circle ALL answers that apply</u>
<u>(there may be more than one correct answer listed)</u>

1. Nitrification can happen to:
   ① Any public water system with free chlorine
   ② Any public water system with chloramines
   ③ Any surface water system
2. A Nitrification Action Plan (NAP) is:
   ① A plan to avoid or respond to nitrification
   ② Required for all public water systems with chloramines
   ③ A short period of sleep
3. Nitrification in a public water system is bad because:
   ① It can destroy the free chlorine residual
   ② It can cause tastes and odors
   ③ It contributes to biofilm in the pipes
   ④ It increases ammonia concentration
4. Nitrifiers are:
   ① Microbes that are naturally present in water
   ② Pathogens
   ③ Either ammonia-oxidizing bacteria (AOB) or nitrite-oxidizing bacteria (NOB)
5. Ammonia goals at sample sites with high water age should be:
   ① Higher than entry point goals
   ② Lower than entry point goals
   ③ Higher than average water age goals
   ④ Lower than average water age goals

6. It is possible to kill nitrifiers in the distribution system by:

   ① Burning them with heat

   ② Starving them by removing their food source

   ③ Acidifying them with citric acid

7. A NAP baseline or goal level is:

   ① 4 mg/L

   ② A normal level when things are going well

   ③ The same for all public water systems

   ④ A trigger to take corrective action

8. The reason to develop a NAP is to:

   ① Prepare for the inevitable

   ② Understand what to look out for to avoid advanced nitrification

   ③ Understand who is supposed to do what when it is time for corrective action

9. Sites sampled as part of your NAP:

   ① Must include all Revised Total Coliform Rule (RTCR) sampling sites

   ② Must include trihalomethane (THM) sampling sites

   ③ Must include sites representing average and maximum water age.

   ④ Must be at active service connections

10. Methods used for all NAP sample analyses must be.

   ① Accurate

   ② Approved by TCEQ

   ③ Approved by NELAC

11. Nitrite and nitrate need to be sampled as part of the NAP:

   ① True

   ② False

12. When our PWS is doing a temporary free chlorine conversion:

   ① We tell TCEQ

   ② We tell wholesale customers

   ③ We don't tell anyone

   ④ We don't tell the customer that complains every month

   ⑤ We can tell medical facilities but it is not required

13. If a routine nitrite sample in distribution is above the baseline:

① Nitrification is definitely occurring

② A backflow or cross connection event may be occurring

③ Nitrification may be occurring

④ The sample site is probably contaminated

14. Some examples of actions that might be part of a NAP are:

① Take more samples

② Replace large mains

③ Verify sample results

④ Determine the area impacted

⑤ Get a fuzzy blanket

15. If a routine total chlorine sample is lower than a yellow flag alert trigger:

① Action should be taken immediately

② Managers should be notified

③ The national news media should be notified immediately

④ A free chlorine conversion should be scheduled

Notes

DAM 8 Attachment 2b:
Post-Test

Instructions: The Pre- and Post-Tests are intended to help you evaluate your learning. All staff who participate in this training event should complete this Pre-Test. Answer all questions to the best of your ability. After the Post-Test is done, the Instructor will go over the correct answers.

Training location: ______________________________

Position: ○ Operator ○ Administrator ○ Other

Circle ALL answers that apply
(there may be more than one correct answer listed)

1. Nitrification can happen to:
   ① Any public water system with free chlorine
   ② Any public water system with chloramines
   ③ Any surface water system
2. A Nitrification Action Plan (NAP) is:
   ① A plan to avoid or respond to nitrification
   ② Required for all public water systems with chloramines
   ③ A short period of sleep
3. Nitrification in a public water system is bad because:
   ① It can destroy the free chlorine residual
   ② It can cause tastes and odors
   ③ It contributes to biofilm in the pipes
   ④ It increases ammonia concentration
4. Nitrifiers are:
   ① Microbes that are naturally present in water
   ② Pathogens
   ③ Either ammonia-oxidizing bacteria (AOB) or nitrite-oxidizing bacteria (NOB)
5. Ammonia goals at sample sites with high water age should be:
   ① Higher than entry point goals
   ② Lower than entry point goals
   ③ Higher than average water age goals
   ④ Lower than average water age goals

6. It is possible to kill nitrifiers in the distribution system by:

   ① Burning them with heat

   ② Starving them by removing their food source

   ③ Acidifying them with citric acid

7. A NAP baseline or goal level is:

   ① 4 mg/L

   ② A normal level when things are going well

   ③ The same for all public water systems

   ④ A trigger to take corrective action

8. The reason to develop a NAP is to:

   ① Prepare for the inevitable

   ② Understand what to look out for to avoid advanced nitrification

   ③ Understand who is supposed to do what when it is time for corrective action

9. Sites sampled as part of your NAP:

   ① Must include all Revised Total Coliform Rule sampling sites

   ② Must include trihalomethane (THM) sampling sites

   ③ Must include sites representing average and maximum water age.

   ④ Must be at active service connections

10. Methods used for all NAP sample analyses must be.

   ① Accurate

   ② Approved by TCEQ

   ③ Approved by NELAC

11. Nitrite and nitrate need to be sampled as part of the NAP:

   ① True

   ② False

12. When our PWS is doing a temporary free chlorine conversion:

   ① We tell TCEQ

   ② We tell wholesale customers

   ③ We don't tell anyone

   ④ We don't tell the customer that complains every month

   ⑤ We can tell medical facilities but it is not required

13. If a routine nitrite sample in distribution is above the baseline:

① Nitrification is definitely occurring

② A backflow or cross connection event may be occurring

③ Nitrification may be occurring

④ The sample site is probably contaminated

14. Some examples of actions that might be part of a NAP are:

① Take more samples

② Replace large mains

③ Verify sample results

④ Determine the area impacted

⑤ Get a fuzzy blanket

15. If a routine total chlorine sample is lower than a yellow flag alert trigger:

① Action should be taken immediately

② Managers should be notified

③ The national news media should be notified immediately

④ A free chlorine conversion should be scheduled

Notes

DAM 8 Attachment 3: Training Evaluation Form

To be completed by trainees who participated in the DAM.

PWS Name: ______________________________ Date: ____________

Instructor Name: ______________________________

Overall Evaluation: (Agree = 1, Disagree = 5)

① Strongly Agree ② Agree ③ No Opinion ④ Disagree ⑤ Strongly Disagree

Question:	←Agree/Disagree→
1. The DAM agenda accurately described the materials and activities that were covered.	① ② ③ ④ ⑤
2. The technical aspects of the DAM activities were appropriate for the participants.	① ② ③ ④ ⑤
3. The DAM activities were reasonably timed and covered the right amount of information.	① ② ③ ④ ⑤
4. The participant handouts were understandable and helpful in completing DAM activities.	① ② ③ ④ ⑤
5. The presentation adequately covered the NAP concepts.	① ② ③ ④ ⑤
6. Chapter 1 adequately explained nitrification.	① ② ③ ④ ⑤
7. Chapter 2 explained mapping and graphing	① ② ③ ④ ⑤
8. Chapter 2 adequately explained setting goals for total chlorine, monochloramine, and ammonia and baselines for nitrite and nitrate.	① ② ③ ④ ⑤
9. Chapter 3 helped me understand the actions needed to respond to triggers.	① ② ③ ④ ⑤
10. Chapter 4 helped identify internal and external communication that will help successfully implement the NAP.	① ② ③ ④ ⑤
11. Chapter 5 will help us develop the NAP matrix and put the NAP together to attach to the Monitoring Plan.	① ② ③ ④ ⑤
12. The DAM will help us control and prevent future nitrification events in our distribution system.	① ② ③ ④ ⑤
13. We will complete the items we identified on the Plan of Action that was developed during this training.	① ② ③ ④ ⑤
14. The DAM was exactly what we needed.	① ② ③ ④ ⑤

LOCATION: ______________________________________ Date: ________________

Specific Suggestions:

What could we change to improve this Directed Assistance Module?

What did we not explain well enough for you to understand?

What areas did we spend too much time on?

What areas did we spend too little time on?

What are some other issues where you feel more training is needed?

What other comments or suggestions do you have?

DAM 8 Attachment 4: Plan of Action

This form is intended to help you follow up on any items that you did not finish during the DAM itself. **Detach this from the NAP DAM Student Guide first thing** in the day. During the day, jot down items that you need to follow up on from each workshop.

- Document what needs to be done, who needs to get it done, and when it needs to be done. Every action item should have a person assigned, and a deadline.
- For large items, consider the first step, second step, and so on. It is okay if the first step is to "Make a timeline on completing the new pipeline" or something like that.

After the NAP DAM, copy all of the Action Items on to your normal calendar or task list—or communicate the tasks to the people who will be assigned to them.

Plan of Action!

ACTION ITEM	PERSON TO ACT	DEADLINE

Note: Use additional paper if needed.

Notes

Revision table

Date	Action	Comment
August 2015	Created	Version 1
10/12/2015	Revised: Version 2	Add activity lists
11/12/2015	Revised: Version 2	Updated to include Classroom CEU elements
5/20/2016	Revised: Version 3	Format for printing and revise Pre/Post-Tests
2/5/2018	Revised: Version 4	Revise to coordinate with updates to DAM 5: Chloramines, including edits from Train-the-Trainer held 1/30/18
June 2019	Revised: Version 4	Made accessible to meet TCEQ accessibility standards

Thanks for participating in this Directed Assistance Module (DAM)