United States
Environmental Protection
Agency

# STAGE 2 DISINFECTANTS AND DISINFECTION BYPRODUCTS RULE

# CONSECUTIVE SYSTEMS GUIDANCE MANUAL (DRAFT)

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# Purpose

The purpose of this guidance manual is solely to help consecutive systems understand and meet the requirements of the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR). This guidance is not a substitute for applicable legal requirements, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on any party, including EPA, States, or the regulated community. Interested parties are free to raise questions and objections to the guidance and the appropriateness of using it in a particular situation. The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

## Authorship

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**Appendices**

# EXHIBITS

# ACRONYMS

| | |
|---|---|
| §141.2 | Code of Federal Regulations, Title 40, Section 141.2 |
| AWWA | American Water Works Association |
| AwwaRF | American Water Works Association Research Foundation |
| BATs | Best available technologies |
| CCR | Consumer Confidence Report |
| CFD | Computational fluid dynamics |
| CNBr | Cyanobromides |
| CNCl | Cyanochlorides |
| CNX | Cyanohalides |
| CT | Disinfectant residual concentration × contact time |
| DBP | Disinfection byproduct |
| DBPR | Disinfectants and Disinfection Byproducts Rule |
| DPD | N, N-diethyl-p-phenylenediamine |
| EPA | United States Environmental Protection Agency |
| IDSE | Initial Distribution System Evaluation |
| GAC | Granular activated carbon |
| GWUDI | Ground water under the direct influence of surface water |
| HAA | Haloacetic acid |
| HAA5 | The sum of five HAA species |
| HPC | Heterotrophic plate count |
| IDSE | Initial distribution system evaluation |
| LCR | Lead and Copper Rule |
| LRAA | Locational running annual average |
| LT2ESWTR | Long Term 2 Enhanced Surface Water Treatment Rule |
| MCL | Maximum contaminant level |
| M-DBP | Microbial-disinfection byproducts |
| mg/L | Milligrams per liter |
| mL | Milliliter |
| MRDL | Maximum residual disinfectant level |
| N.d. | No date (for publication) |
| NDMA | N-nitrosodimethylamine |
| NPDWR | National Primary Drinking Water Regulation |
| NOM | Natural organic matter |
| NTNCWS | Nontransient noncommunity water system |
| PAC | Powdered activated carbon |
| PWS | Public water system |
| RAA | Running annual average |
| SDWA | Safe Drinking Water Act |
| SSS | System specific study |
| SWTR | Surface Water Treatment Rule |
| TCR | Total Coliform Rule |
| THM | Trihalomethane |
| TOC | Total organic carbon |
| TTHM | Total trihalomethanes |
| UV | Ultraviolet |

| | |
|---|---|
| VSS | Very small system |
| WTP | Water treatment plant |

# GLOSSARY

*Booster disinfection*: the practice of adding disinfectant in the distribution system to maintain disinfectant residual concentration throughout the distribution system.

*Combined distribution system*: the interconnected distribution system consisting of the distribution systems of wholesale systems and of the consecutive systems that receive some or all of their finished water from those wholesale system(s). (§141.2)

*Community water system*: a public water system that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. (§141.2)

*Consecutive system*: a public water system that buys or otherwise receives some or all of its finished water from one or more wholesale systems. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems. (§141.2)

*Disinfectant*: any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone added to water in any part of the treatment or distribution process, that is intended to kill or inactivate pathogenic microorganisms. (§141.2)

*Disinfectant residual concentration*: the concentration of disinfectant that is maintained in a distribution system. Disinfectant could be free chlorine (the sum of the concentrations of hypochlorous acid and hypochlorite acid or combined chlorine (chloramines). It is used in the Surface Water Treatment Rule as a measure for determining CT.

*Disinfection*: a process that inactivates pathogenic organisms in water by chemical oxidants or equivalent agents. (§141.2)

*Disinfection byproduct (DBP)*: compound formed from the reaction of a disinfectant with organic and inorganic compounds in the source or treated water during the disinfection process.

*Finished water*: water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except that treatment necessary to maintain water quality in the distribution system (e.g., booster disinfection, addition of corrosion control chemicals). (§141.2)

*Ground water under the direct influence of surface water (GWUDI)*: any water beneath the surface of the ground with (1) significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as *Giardia lamblia*, or (2) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH that closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the State. The State determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation. (§141.2)

*Haloacetic acid (HAA)*: one of the family of organic compounds named as a derivative of acetic acid, wherein one to three hydrogen atoms in the methyl group in acetic acid are each substituted by a halogen atom (namely, chlorine and bromine) in the molecular structure.

*Haloacetic acids* (five) (HAA5): the sum of the concentrations in milligrams per liter of the haloacetic acid compounds (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid), rounded to two significant figures after addition. (§141.2)

*Heterotrophic plate count (HPC)*: a procedure for estimating the number of heterotrophic bacteria in water, measured as the number of colony forming units per 100 mL.

*Locational running annual average* (LRAA): the average of sample analytical results for samples taken at a particular monitoring location during the previous four calendar quarters. (§141.2)

*Maximum contaminant level (MCL)*: the maximum permissable level of a contaminant in water that is delivered to any user of a public water system. (§141.2)

*Mixing zone*: an area in the distribution system where water flowing from two or more different sources blend.

*Monitoring site*: the location where samples are collected.

*Nitrification*: a two-step process in which nitrifying bacteria convert ammonia to nitrite and then convert nitrite to nitrate. Nitrification can occur in water distribution systems in which naturally occurring ammonia is present, or in systems that add ammonia to the water as part of the chloramine disinfection process.

*Noncommunity water system*: a public water system that is not a community water system. (§141.2)

*Nontransient noncommunity water system* (NTNCWS): a public water system that is not a community water system and that regularly serves at least twenty-five of the same persons over six months per year. (§141.2)

*Public water system* (PWS): a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. A public water system is either a community water system or a noncommunity water system. (§141.2)

*Residence time*: the time period lasting from when the water is treated to a particular point in the distribution system. Also referred to as water age.

*Running annual average*: the average of monthly or quarterly averages of all samples taken throughout the distribution system, as averaged over the preceding four quarters.

*Secondary disinfection*: The process whereby a disinfectant (typically chlorine or chloramine) is added to finished water in order to maintain a disinfection residual in the distribution system. Also referred to as "residual disinfection".

*State*: the agency of the State or Tribal government that has jurisdiction over public water systems. During any period when a State or Tribal government does not have primary enforcement responsibility pursuant to section 1413 of the Act, the term State means the Regional Administrator, U.S. Environmental Protection Agency. (§141.2)

*Surface water*: all water that is open to the atmosphere and subject to surface runoff. (§141.2)

*Total chlorine residual*: the sum of combined chlorine (chloramine) and free available chlorine residual.

*Total trihalomethanes (TTHM)*: the sum of the concentration in milligrams per liter of the trihalomethane compounds (trichloromethane [chloroform], dibromochloromethane, bromodichloromethane, and tribromomethane [bromoform]), rounded to two significant figures. § 141.2 Note: Some publications may use "THM4" instead of "TTHM".

*Tracer study*: a procedure for estimating hydraulic properties of the distribution system, such as residence time. Where more than one water source feeds the distribution system, tracer studies can be used to determine the zone of influence of each source.

*Trihalomethane* (THM): one of the family of organic compounds named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure. (§141.2)

*Water distribution system model*: a computer program that can simulate the hydraulic, and in some cases, water quality behavior of water in a distribution system.

*Wholesale system*: a public water system that treats source water as necessary to produce finished water and then sells or otherwise delivers finished water to another public water system. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems. (§141.2)

# 1.0 Introduction

## 1.1 Purpose of this Manual

The intent of this manual is to help consecutive systems understand and meet the requirements of the Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR). The Stage 2 DBPR defines a consecutive system as a public water system (PWS) that receives some or all of its finished water from one or more wholesale systems. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems. Consecutive systems that use a disinfectant other than ultraviolet (UV) light or that deliver water from another system that has been treated with a disinfectant other than UV light are subject to the Stage 2 DBPR.

Most Safe Drinking Water Act (SDWA) regulations promulgated to date have not specifically addressed consecutive system requirements. Under the provisions of § 141.29, a State may, with concurrence of the United States Environmental Protection Agency (EPA), have modified monitoring requirements for a consecutive system to the extent that the interconnection of a wholesale and a consecutive system justifies treating them as a single system for monitoring purposes. Therefore, a consecutive system may not have been required by the State to conduct monitoring for certain contaminants if the wholesale system has already monitored for those contaminants.

The Stage 2 DBPR does not change § 141.29, so a State may still modify monitoring requirements, with EPA's concurrence, for consecutive systems as described above. However, a State has the flexibility to require a consecutive system to conduct its own distribution system monitoring for disinfection byproducts (DBP) depending on factors such as the size of the consecutive system's distribution system, the amount of distribution storage, and the quality of the source water.

The Stage 2 DBPR may present certain challenges for consecutive systems. For example, a consecutive system may receive water that has been disinfected and already contains elevated levels of DBP. A consecutive system usually has no treatment facilities to control DBPs already present in the water from the wholesale system, and limited ability to control the continued formation of DBP in its own distribution system. For this reason, EPA has established Best Available Technologies (BATs) specifically for consecutive systems in the Stage 2 DBPR.

EPA is aware of the difficulty in implementing consecutive system regulations because the relationships between wholesale and consecutive systems are complex and varied. EPA is also aware that there are a variety of State approaches to addressing regulatory requirements for consecutive systems. The Stage 2 DBPR presents an opportunity for consecutive systems to better define roles and responsibilities through discussions with their wholesaler and the State. Some States have taken a very active role in establishing relationships between wholesale and consecutive systems.

As discussed later in this document, some of the deadlines imposed by the Stage 2 DBPR (deadlines related to the Initial Distribution System Evaluation (IDSE)) fall within six months of rule promulgation. Although EPA has already provided guidance for consecutive systems to comply with IDSE requirements, all consecutive systems, including those not previously required to comply with the Stage 1 DBPR, are encouraged to contact their wholesaler and their State to confirm their responsibilities for Stage 2 maximum contaminant level (MCL) compliance. EPA has also provided other guidance, where appropriate, to assist PWSs and States in implementing the Stage 2 DBPR.

## 1.2 Manual Organization

This guidance manual is organized as follows:

- Chapter 1 - Introduction: Explains the purpose of this manual.

- Chapter 2 - Overview of Existing Regulatory Requirements for Consecutive Systems: Provides an overview of the provisions of existing regulations that apply to consecutive systems.

- Chapter 3 - Stage 2 DBPR Requirements for Consecutive Systems: Provides an overview of the Stage 2 DBPR requirements that apply to consecutive systems.

- Chapter 4 - Compliance Options for Consecutive Systems: Discusses BATs identified by EPA for consecutive systems to decrease DBP formation in their systems.

- Chapter 5 - Other Alternatives for Consecutive Systems: Discusses alternatives other than BATs for consecutive systems to reduce DBP formation in their systems.

- Chapter 6 - Communication Strategies for Consecutive and Wholesale Systems: Describes communication strategies for consecutive systems needing to coordinate with wholesale systems to meet Stage 2 DBPR requirements.

- Chapter 7 - Compliance Strategies for the Consecutive System: Suggests approaches for consecutive systems in characterizing DBP formation in their system and how to coordinate with the wholesaler on control strategies.

- Chapter 8 - Frequently Asked Questions: Provides answers to questions frequently asked by systems and States.

- Chapter 9 - References: Provides a bibliographic list of references cited in this manual.

Appendix A provides an example of a formal agreement between consecutive and wholesale systems that meets the requirements of the State of Colorado. Other States may have specific requirements that must be met in preparing these agreements.

This guidance manual is intended to address consecutive system-specific issues and contains many references to rules other than the Stage 2 DBPR that may apply to consecutive systems. References to appropriate guidance manuals are provided throughout this document. Copies of these manuals can be obtained by:

- Contacting the appropriate State office

- Calling the Safe Drinking Water Hotline at 1-800-426-4791

- Downloading from EPA's Web site at http://www.epa.gov/safewater or the specific link cited in the reference.

- Calling the National Service Center for Environmental Publications at 1-800-490-9198 or visiting their Web site at http://www.epa.gov/ncepihom .

# 2.0 Overview of Existing Regulatory Requirements for Consecutive Systems

There are several existing drinking water regulations that contain provisions specifically for consecutive systems. This chapter reviews the following regulations that address consecutive system requirements:

- Public Notification Rule

- Consumer Confidence Report (CCR) Rule

- Consecutive System Monitoring Requirements Under § 141.29

## 2.1 Public Notification Rule

The Public Notification Rule requires the owner or operator of any PWS to notify its customers any time it incurs a violation of a national primary drinking water regulation (NPDWR) and in other specific situations. The type of notification required varies depending on the violation. Exhibit 2.1 shows the tier of notification required for certain types of violations or situations as well as the notification frequency and method for each tier.

PWSs that sell or provide water to another public water system must give public notice to its own customers as well as the owner or operator of the consecutive system (§141.201(c)(1)). The consecutive system is then responsible for providing public notice to its own customers. If the violation occurs in a portion of the distribution system that is physically or hydraulically isolated from other parts of the distribution system, the State may allow the system to limit public notification only to customers in that area of the distribution system. However, the system must receive permission from the State in writing to limit distribution of the public notice (§ 141.201(c)(2)).

### Exhibit 2.1 Tiers of Public Notice

| Tier | Types of Situations | When Notice is Required | Examples of Appropriate Notification Methods[1] |
|---|---|---|---|
| 1 | NPDWR violations and situations with significant potential to have serious adverse effects on human health as a result of short-term exposure. | • As soon as practical but no later than 24 hours after the system learns of violation.<br>• Consult with State as soon as practical but no later than 24 hours after learning of the violation to determine additional public notification requirements. | • Broadcast media<br>• Posting in conspicuous location<br>• Hand delivery<br>• Other method approved by State |
| 2 | All other NPDWR violations and situations with potential to have serious adverse effects on human health. | • As soon as practical but no later than 30 days after the system learns of violation.<br>• Repeat notice required every 3 months or as determined by State for as long as violation or situation persists | • Mail or other direct delivery<br>• Newspaper notice<br>• Posting in public places<br>• Posting on the internet<br>• Delivery to community organizations |
| 3 | All other NPDWR violations and situations not included in Tier 1 and Tier 2. | • No later than 1 year after system learns of violation.<br>• Repeat notice required annually. | • Mail or other direct delivery<br>• Newspaper notice<br>• Posting in public places<br>• Posting on the internet<br>• Delivery to community organizations<br>• Inclusion in consumer confidence report |

[1] Note that some notification methods are only available to certain types of systems.

For more information on Public Notification Rule requirements, refer to:

- *Public Notification Handbook* (USEPA, 2000a)
- *The Public Notification Rule: A Quick Reference Guide* (USEPA, 2000b)

## 2.2 Consumer Confidence Report (CCR) Rule

The CCR Rule requires community water systems to provide an annual report to their customers that provides information on the quality of the water delivered by the system and any risks from exposure to contaminants detected in the water. The report must be distributed by July 1 of each year and must contain data collected during or prior to the previous calendar year. Consecutive systems should include information about all purchased water in their CCRs. Wholesale systems are required to deliver the applicable water quality information to consecutive systems no later than April 1 of each year or by a date mutually agreed upon and included in a contract between the consecutive and wholesale system (§ 141.152(d)).

For more information on CCR requirements refer to:

- *Preparing Your Consumer Confidence Report: Revised Guidance for Water Suppliers* (USEPA, 2005)

- *Consumer Confidence Report Rule: A Quick Reference Guide* (USEPA, 2004b)

## 2.3 Consecutive Systems Monitoring Requirements (§ 141.29)

The provisions for consecutive systems under § 141.29 allow the State to modify the requirements for combined distribution systems. When justified, the State may treat the combined distribution system as a single system for monitoring purposes. Such systems must follow a monitoring schedule specified by the State and concurred with by the Administrator of the EPA.

# 3.0 Stage 2 DBPR Requirements for Consecutive Systems

Many consecutive systems deliver water that has been treated with a disinfectant other than UV light and which may therefore contain DBPs. Prior to promulgation of the Stage 2 DBPR, monitoring of consecutive systems for DBPs was not specifically addressed by SDWA regulations. The intent of the Stage 2 DPBR with respect to consecutive systems is to present an effective approach for identifying and resolving DBP problems, keeping in mind that relationships between wholesale systems and consecutive systems are often complex and varied. Depending upon the specific nature of these relationships, States have some flexibility in their approach to the implementation of the Stage 2 DBPR requirements. Consecutive systems are encouraged to contact their wholesale systems and their States as soon as possible after rule promulgation to discuss applicable requirements and responsibilities.

This chapter describes the requirements of the Stage 2 DBPR that apply to consecutive systems. The following rule requirements are discussed:

- Disinfection Byproduct MCLs;
- IDSEs;
- Stage 2 (subpart V) Compliance Monitoring Requirements;
- Disinfectant Residual Monitoring; and
- Operational Evaluations.

## 3.1 Disinfection Byproduct Maximum Contaminant Levels

The MCLs for total trihalomethanes (TTHM) and haloacetic acid (five) (HAA5) have not changed from the Stage 1 DBPR; however, the method of calculating compliance has changed. For more information on Stage 2 DBPR compliance calculations, refer to Section 3.4. The MCLs for DBPs are shown in Exhibit 3.1. The deadlines for complying with these MCLs are shown in Exhibit 3.2.

**Exhibit 3.1 DBP MCLs**

| Disinfection Byproduct | MCL (mg/L) |
|---|---|
| Bromate | 0.010 |
| Chlorite | 1.0 |
| TTHM | 0.080 |
| HAA5 | 0.060 |

**Exhibit 3.2 Stage 2 DBPR Compliance Schedule for Wholesale and Consecutive Systems**

| Population Served by the Largest System in the Combined Distribution System[1] | Deadline for Compliance with Stage 2 DBPR (subpart V) Monitoring Requirements[2] |
|---|---|
| ≥ 100,000 people | April 1, 2012 |
| 50,000 - 99,999 people | October 1, 2012 |
| 10,000 - 49,999 people | October 1, 2013 |
| < 10,000 people | October 1, 2013 if no *Cryptosporidium* monitoring is required under LT2ESWTR<br>OR<br>October 1, 2014 if *Cryptosporidium* monitoring is required under LT2ESWTR |

[1] A combined distribution system consists of the distribution systems of wholesale systems and of the consecutive systems that receive some or all of their finished water from those wholesale system(s) (§ 141.2).

[2] If you are required to conduct quarterly monitoring, you must begin monitoring in the first full calendar quarter that includes the compliance date in Exhibit 3.2. If you are required to conduct monitoring at a frequency that is less than quarterly, you must begin monitoring in the calendar month recommended in the IDSE report (§ 141.601 or 141.602) or the calendar month identified in the subpart V monitoring plan (141.622) no later than 12 months after the date listed in Exhibit 3.2. The State may grant up to an additional 24 months for compliance if you require capital improvements to comply with an MCL.

## 3.2 Initial Distribution System Evaluation

This section briefly summarizes the Stage 2 DBPR IDSE requirements. For more information on Stage 2 IDSE requirements, refer to the *Initial Distribution System Evaluation (IDSE) Guidance Manual for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule* (USEPA, 2006a). A separate guide has also been developed to briefly summarize the requirements for systems serving fewer than 10,000 people (USEPA, 2006b).

Community water systems of any size and nontransient, noncommunity water systems (NTNCWS) serving at least 10,000 people are subject to the IDSE requirements if they use a primary or residual disinfectant other than UV light or deliver water that has been treated with a primary or residual disinfectant other than UV light. The purpose of the IDSE requirements is to help systems select representative high TTHM and HAA5 compliance monitoring locations. These sites are then used for compliance monitoring under the Stage 2 DBPR.

There are four options available for systems to meet IDSE requirements, depending on their historical sampling data, size, and preference:

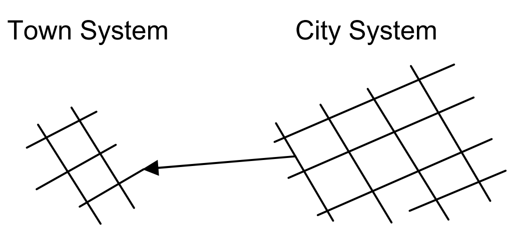
- Receive a **Very Small System (VSS) Waiver**. Systems serving fewer than 500 people may be eligible for a waiver from the State. Systems receiving the waiver have no further IDSE requirements.

- Receive **40/30 certification**. A system has no further IDSE requirements if the system can certify to the State that all TTHM and HAA5 compliance data are less than or equal to 0.040 mg/L for TTHM and 0.030 mg/L for HAA5 during a specified two year period. In addition, the system must not have had any TTHM or HAA5 monitoring violations during the same period.

- Conduct a **System Specific Study (SSS)**. A system may conduct an IDSE study based on existing monitoring results or a hydraulic model instead of conducting IDSE standard monitoring. A system's model or existing monitoring results must meet specific criteria to be used in an SSS.

> The State sent a letter to each system with a determination of the system's IDSE schedule based on system characteristics. The compliance schedule for consecutive and wholesale systems was based on the population of the largest system in the combined distribution system. For purposes of complying with the IDSE schedule, the State may have determined that the combined distribution system does not include certain consecutive systems based on factors such as receiving water from a wholesale system only on an emergency basis or receiving only a small percentage and small volume of water from a wholesale system. The State may also have determined that the combined distribution system does not include certain wholesale systems based on factors such as delivering water to a consecutive system only on an emergency basis or delivering only a small percentage and small volume of water to a consecutive system.

- Conduct **Standard Monitoring**. IDSE standard monitoring entails one year of distribution system monitoring. The sampling frequency and minimum number of sample locations required depend on system characteristics such as size, source water type, and whether the system is part of a combined distribution system.

> A **combined distribution system** consists of the distribution systems of wholesale systems and of the consecutive systems that receive some or all of their finished water from those wholesale system(s) (§ 141.2). For example, if a Town purchases water from a City to supplement its own groundwater supplies, the combined distribution system includes the City's and the Town's distribution systems.
>
> 
> 

Consecutive systems that do not apply a chemical disinfectant were not specifically addressed by Stage 1 DBPR requirements. Therefore, these systems may not have historical TTHM and HAA5 data unless the wholesale system collected samples within the consecutive system. In the absence of historic TTHM and HAA5 data, systems must either conduct standard monitoring or an SSS to comply with the IDSE requirements. Consecutive systems should consider obtaining Stage 1 data from the wholesaler to assist in IDSE site selection if no historical data exists.

## 3.3 Stage 2 (subpart V) Compliance Monitoring Requirements

This section provides a brief summary of the Stage 2 (subpart V) compliance monitoring requirements. For more information on Stage 2 DBPR monitoring, reporting, and recordkeeping requirements, refer to:

- *Stage 2 DBPR Operational Evaluation Guidance Manual* (*USEPA, N.d.*)
- *Initial Distribution System Evaluation Guidance Manual for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule* (USEPA, 2006)
- *Complying with the Stage 2 Disinfectant and Disinfection Byproducts Rule: Small Entity Compliance Guide* (USEPA 2007c).

A system is subject to the Stage 2 (subpart V) requirements if it is a community water system or a NTNCWS and it uses a primary or residual disinfectant other than UV light or delivers water that has been treated with a primary or residual disinfectant other than UV light. Therefore, consecutive systems that do not apply a disinfectant but purchase water that has been treated with a disinfectant must comply with these requirements. In addition, these consecutive systems must now comply with the Stage 1 DBPR analytical, monitoring, and maximum residual disinfectant level (MRDL) requirements for chlorine and chloramines. The chlorine and chloramine requirements are discussed further in Section 3.5.

The MCLs for TTHM and HAA5 have not changed from the Stage 1 DBPR. However, the method of calculating compliance has changed. Stage 2 DBPR compliance determination is based on locational running annual averages (LRAAs) of TTHM and HAA5 concentrations. Compliance must be met at *each* monitoring location, instead of using the system-wide running annual average (RAA) required under the Stage 1 DBPR.

### 3.3.1 Stage 2 DBPR Monitoring Plan

Systems must develop a monitoring plan to be used for Stage 2 monitoring and compliance determination (§ 141.622). The monitoring plan must include:

- Monitoring locations;
- Monitoring dates;
- Compliance calculation procedures; and
- Monitoring plans for any other systems in the combined distribution system if the State has reduced monitoring requirements.

Note that many systems will recommend Stage 2 DBPR compliance monitoring locations and dates as part of their IDSE report.

Systems using surface water, ground water under the direct influence of surface water (GWUDI), or purchased surface water and serving more than 3,300 people must submit a copy of the monitoring plan to the State prior to the date they are scheduled to collect their first Stage 2 DBPR compliance samples. All systems must keep the plan on file for State and public review. A system that has been granted a VSS waiver must comply by updating its Stage 1 monitoring plan.

Systems may make modifications to their monitoring plan to reflect changes in treatment, distribution system operations and layout (including new service areas), or other factors that may affect TTHM or HAA5 formation. The State may also require modifications to the monitoring plan.

### 3.3.2 Stage 2 DBPR Compliance Monitoring

*Routine Monitoring*

The Stage 2 DBPR routine monitoring requirements are shown in Exhibit 3.3. Systems must comply with Stage 2 DBPR monitoring requirements by the deadlines shown in Exhibit 3.2 according to their Stage 2 DBPR monitoring plan. Consecutive and wholesale systems must determine their compliance schedules based on the population of the largest system in the combined distribution system.

*Modified Monitoring for Combined Distribution Systems*

The State is allowed to modify the Stage 2 DBPR monitoring requirements of wholesale and consecutive systems on a case by case basis (§ 142.16(m)). These modifications would allow the State to account for complex combined distribution systems, such as the following cases (USEPA, 2007b):

- Neighboring systems that buy and sell to each other regularly throughout the year;

- Situations where water passes through multiple consecutive systems before it reaches the user; and

- A large group of interconnected systems.

The modified monitoring program must not undermine public health protection (USEPA, 2007b). The State may reduce the number of monitoring sites required for individual systems if the reduced number adequately represents DBP levels throughout the distribution system. The combined distribution system must have at least the minimum number of Stage 2 DBPR monitoring sites and monitoring frequency shown in Exhibit 3.3 based on the source water type and total population of the combined distribution system. In addition, each consecutive or wholesale system must have at least one compliance monitoring location.

Systems should note that regulatory requirements present the minimum acceptable monitoring program. Monitoring above and beyond regulatory requirements is advised if the system has adequate resources. The additional monitoring data can help the system to be proactive in identifying areas of the distribution system with potentially high DBP levels, and to optimize operating practices to minimize DBP levels.

There is a primacy requirement for States to decide how they will handle monitoring in consecutive systems. "States can satisfy this special primacy condition regarding consecutive system monitoring by including a copy of the procedure they will use for addressing consecutive systems outside the provisions of § 141.29. Alternatively, States can simply attest that they will not use an authority to address consecutive system monitoring outside of § 141.29."

Consecutive systems are responsible for ensuring that required monitoring is completed and the system is in compliance. Each consecutive system must base compliance on samples collected within its distribution system. The consecutive system may conduct the monitoring itself or arrange for the monitoring to be done by the wholesale system or another outside party. Whatever approach it chooses, the consecutive system must document its monitoring strategy as part of its DBP monitoring plan.

### Exhibit 3.3 Stage 2 (subpart V) Routine Monitoring Requirements

| Source Water Type | Population Size Category | Monitoring Frequency [1] | Number of Distribution System Monitoring Sites |
|---|---|---|---|
| subpart H | < 500 | per year | 2 [2] |
| | 500 - 3,300 | per quarter | 2 [2] |
| | 3,301 - 9,999 | per quarter | 2 |
| | 10,000 - 49,999 | per quarter | 4 |
| | 50,000 - 249,999 | per quarter | 8 |
| | 250,000 - 999,999 | per quarter | 12 |
| | 1,000,000 - 4,999,999 | per quarter | 16 |
| | ≥ 5,000,000 | per quarter | 20 |
| Ground Water | < 500 | per year | 2 [2] |
| | 500 - 9,999 | per year | 2 |
| | 10,000 - 99,999 | per quarter | 4 |
| | 100,000 - 499,999 | per quarter | 6 |
| | ≥ 500,000 | per quarter | 8 |

[1] All systems must take at least one dual sample set during the month of highest DBP concentrations. Systems on quarterly monitoring (except for subpart H systems serving 500-3,300 people) must take dual sample sets every 90 days.

[2] System is required to take individual TTHM and HAA5 samples (instead of a dual sample set) at the locations with the highest TTHM and HAA5 concentrations, respectively. Only one location with a dual sample set per monitoring period is needed if highest TTHM and HAA5 concentrations occur at the same location.

*Reduced Monitoring*

Systems may reduce the number or frequency of samples taken if all of the following occur:

- The LRAA is less than or equal to 0.040 mg/L for TTHM and 0.030 mg/L for HAA5 at each monitoring location.

- Only data collected under the Stage 2 DBPR or Stage 1 DBPR (if you monitor at the same Stage 1 locations for Stage 2) are used to qualify for reduced monitoring.

- The source water annual average total organic carbon (TOC) level, before any treatment, is less than or equal to 4.0 mg/L at each treatment plant treating surface water or GWUDI based on monitoring conducted under the Stage 1 DBPR. Contact your wholesaler to see if data are available.

Systems that were on reduced TTHM and HAA5 monitoring under the Stage 1 DBPR may remain on reduced monitoring under the Stage 2 DBPR if all of the above criteria are met and the system qualified for 40/30 certification or received a VSS waiver.

Systems may remain on reduced monitoring for as long as the following occur:

- For systems on quarterly monitoring, the LRAA is less than or equal to 0.040 mg/L for TTHM and 0.030 mg/L for HAA5 at each monitoring location

- For systems on annual or less frequent monitoring, each TTHM sample is less than or equal to 0.060 mg/L and each HAA5 sample is less than or equal to 0.045 mg/L.

- The source water annual average TOC level, before any treatment, is less than or equal to 4.0 mg/L at each treatment plant treating surface water or GWUDI based on monitoring conducted under the Stage 1 DBPR.

However, States may require systems to return to routine monitoring at their discretion. For example, if a system makes significant changes to its treatment or distribution system or if a system changes monitoring locations, the State may require the system to return to routine monitoring.

*Increased Monitoring*

Systems that are required to monitor at a particular location yearly or less frequently under routine or reduced monitoring must begin increased monitoring at all locations if a TTHM sample is greater than 0.080 mg/L or an HAA5 sample is greater than 0.060 mg/L at any location. The system must increase monitoring to dual sample sets once per quarter at each monitoring location. The system may return to routine monitoring after it conducts increased monitoring for at least four consecutive quarters and the LRAA for every monitoring location is less than or equal to 0.060 mg/L for TTHM and 0.045 mg/L for HAA5. Systems that were on increased monitoring under the Stage 1 DBPR must remain on increased monitoring under the Stage 2 DBPR until the criteria for returning to routine monitoring are met.

### 3.3.3 Reporting and Recordkeeping Requirements

Systems must report the results of Stage 2 (subpart V) TTHM and HAA5 monitoring to the State within 10 days of the end of any quarter in which monitoring is required. Systems conducting quarterly monitoring must calculate the LRAAs for TTHM and HAA5 by averaging the data from the most recent four quarters of monitoring. For systems that conduct monitoring yearly or less frequently, each sample is considered the LRAA for that monitoring location. However, if any single sample has a TTHM or HAA5 concentration greater than the MCL, the system does not incur a violation immediately. Instead, the system must begin increased monitoring.

Systems that are seeking to remain on reduced monitoring must also submit the results of source water TOC monitoring for each surface water or GWUDI source. Note that source water samples must be taken prior to treatment and would probably have to be taken by the wholesaler. Systems must retain all monitoring results for ten years.

## 3.4 Disinfectant Residual Monitoring

Consecutive systems that do not add a chemical disinfectant to the water may not have previously monitored to determine compliance with the MRDLs for chlorine and chloramines. The Stage 2 DBPR now specifically requires consecutive systems that deliver water that has been treated with a disinfectant other than UV light to comply with the following requirements for chlorine and chloramines:

- Analytical requirements in § 141.131(c). This section lists approved methods for chlorine and chloramine residual monitoring. The rule allows systems to use N, N-diethyl-p-phenylenediamine (DPD) kits, among other methods, for measuring these residuals. Only a party approved by EPA or the State may measure the residual disinfectant concentration for compliance.

- Monitoring requirements in § 141.132(c)(1). Systems must measure the residual disinfectant concentration at the same time and location as total coliforms are sampled. Reduced monitoring is not allowed.

- Compliance requirements in § 141.133(c)(1). Systems must determine MRDL compliance using an RAA, computed quarterly, of monthly averages of residual disinfectant samples collected for compliance. If the RAA exceeds the MRDL, the system is in violation of the MRDL and must report to the State and notify the public. Systems that switch between chlorine and chloramines must calculate compliance using results of both chlorine and chloramine residual monitoring together. The MRDL for chlorine is 4.0 mg/L and the MRDL for chloramines is 4.0 mg/L (§ 141.65).

- Reporting requirements in § 141.134(c). Systems must report the results of chlorine and chloramine monitoring to the State by the tenth day of the month following the end of each quarter. Systems must report the number of samples taken during each month of the last quarter, the monthly average for samples taken in each of the last twelve months, the average of all monthly averages for the last twelve months, and whether the MRDL was exceeded. The State may instead choose to perform the calculations and determine compliance for the system.

Systems must comply with these requirements beginning April 1, 2009 unless required to do so earlier by the State.

For more information on Stage 1 DBPR requirements, refer to:

- *The Stage 1 Disinfectants and Disinfection Byproducts Rule: What Does it Mean to you?* (USEPA, 2001)

- *Alternative Disinfectants and Oxidants Guidance Manual (*USEPA, 1999a)

## 3.5 Operational Evaluations

The Stage 2 Microbial-Disinfection Byproducts (M-DBP) Agreement in Principle acknowledges that DBP peaks will sometimes occur, even when systems are in full compliance with the enforceable MCL. The operational evaluation requirements of the Stage 2 DBPR help identify and reduce these peaks. The rule establishes operational evaluation levels of 0.080 mg/L for TTHM and 0.060 mg/L for HAA5. A system exceeds the operational evaluation level at any monitoring location where one of the following occurs:

- The two previous quarters' TTHM results plus twice the current quarter's TTHM result, divided by four, exceeds 0.080 mg/L, or

- The two previous quarters' HAA5 results plus twice the current quarter's HAA5 result, divided by four, exceeds 0.060 mg/L.

A system that exceeds the operational evaluation level must conduct an operational evaluation and submit a written report of the evaluation to the State no later than 90 days after being notified of the analytical result that caused it to exceed the operational evaluation level. The operational evaluation must include an examination of system treatment and distribution operational practices. However, you may request that the State allow you to limit the scope of your operational evaluation if you are able to identify the cause of the operational evaluation level exceedance to the State's satisfaction. The operational evaluation must also include steps that could be considered to minimize the possibility of future operational evaluation level exceedances.

An operational evaluation level exceedance ***is not*** a violation of the Stage 2 DBPR. However, failure to conduct an operational evaluation and submit the report to the State in the required time frame is a violation and requires Tier 3 public notice (as required by the Public Notification Rule).

For more information on operational evaluations refer to EPA's *Stage 2 DBPR Operational Evaluation Guidance Manual* (*USEPA, N.d.*).

### 3.6 Simultaneous Compliance

Systems may encounter compliance issues with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) when making changes to comply with the Stage 2 DBPR, and vice versa. In addition to the challenges of complying with the suite of M-DBP rules simultaneously, a water system operator must also ensure that changes in treatment do not adversely affect compliance with other drinking water regulations, such as the Lead and Copper Rule (LCR) and Total Coliform Rule (TCR). Guidance on how to address these potential conflicts can be found in EPA's *Simultaneous Compliance Guidance Manual* (USEPA, 2007a).

# 4.0 Compliance Options for Consecutive Systems

Consecutive systems purchase finished water from wholesale systems and may have limited control over the quality of water entering the distribution system. Many purchasing agreements specify the quantity of water available to a consecutive system from a wholesale system, but may not include specific water quality requirements. When water quality is included, purchasing agreements may stipulate only that water quality at the consecutive system entry point will meet all State and Federal regulations. However, because DBP concentrations can increase, sometimes significantly, from the consecutive system entry point through the distribution system, consecutive systems may at times have difficulty meeting the Stage 2 DBPR MCLs for TTHM and HAA5. As a result, there will be instances in which it is necessary for consecutive systems to implement treatment and/or operational changes to comply with the Stage 2 DBPR.

This chapter discusses the treatment and operational alternatives most likely to be available to consecutive to control DBP levels in treated water and comply with Stage 2 DBPR. This chapter includes the following sections:

4.1 DBP Control in Consecutive Systems
4.2 Water Age Management
4.3 Reduction of Disinfectant Demand
4.4 Chloramination

## 4.1 DBP Control in Consecutive Systems

Depending on the wholesale system-consecutive system physical arrangement and hydraulic characteristics, DBP concentrations may be higher in the consecutive system than in the wholesale system. This is particularly true when consecutive systems receive water through a distribution grid rather than dedicated transmission mains. In such cases, the water entering the purchasing system may already be several days old. Increased water age generally results in increased distribution system DBP concentrations. Under the Stage 2 DBPR, wholesale systems are not required to make treatment or operational modifications necessary to reduce DBP concentrations in their consecutive systems as long as the wholesale system meets the MCLs within its own distribution system. In such cases it may be necessary for the consecutive system to implement treatment or operational changes to reduce distribution system DBP concentrations and comply with the Stage 2 DBPR.

The treatment or operational changes considered and ultimately implemented by a consecutive system to reduce DBP concentrations will depend on the factor(s) causing the high DBP levels. The factors that most significantly impact DBP formation are:

- Disinfectant type and dose. The type and dose of a disinfectant has a significant impact on DBP formation. Chlorine is the most common primary disinfectant used in water treatment, but it reacts with natural organic matter (NOM) to form chlorinated DBPs such as trihalomethanes (THMs) and haloacetic acids (HAAs). Some of the alternative primary disinfectants to chlorine are chlorine dioxide, ozone, and UV light. While these alternative disinfectants can help to reduce levels of chlorinated DBPs, they form other types of byproducts. Secondary disinfectants used to maintain a residual in the distribution system include chlorine and chloramines.

- Inorganic DBP precursor concentrations. Bromide reacts with chlorine to form hypobromous acid, which is more aggressive in forming DBPs than chlorine (hypochlorous acid). Bromide cannot be cost-effectively removed at this time.

- Organic DBP precursor concentration. NOM reacts with disinfectants to form DBPs. Treatment processes that may help to reduce levels of organic DBP precursors include enhanced coagulation, powdered activated carbon (PAC), granular activated carbon (GAC), ozone and biological filtration, and nanofiltration.

- pH. DBP formation is affected by the pH of the water. Chlorination at higher pH forms a higher amount of THMs, while the opposite is true for HAAs. Water at a higher pH may also require a higher chlorine dose to maintain a consistent level of microbial inactivation before entering the distribution system to comply with the Surface Water Treatment Rule (SWTR). However, changes to pH to control DBPs should be carefully considered to prevent a decrease in corrosion control effectiveness in the distribution system and to avoid possible lead and copper corrosion problems.

- Temperature. Seasonal variations in water temperature during treatment and in the distribution system can have an effect on the reaction rate. Higher temperatures increase reaction rates between DBP precursors and disinfectants to produce higher levels of DBPs.

- Water age. The contact time between disinfectants and DBP precursors has a significant effect on DBP formation. As the reaction time with the disinfectant increases, so does DBP formation. However, biodegradation may actually reduce HAA5 levels if adequate disinfectant residuals are not maintained.

These factors are discussed in greater detail in the Stage 2 DBPR *Initial Distribution System Evaluation (IDSE) Guidance Manual* (USEPA, 2006), *Operational Evaluation Guidance Manual* (*USEPA, N.d.*), and *Stage 2 M-DBP Simultaneous Compliance Guidance Manual* (USEPA, 2007).

Among the major factors identified above, the removal of DBP precursors and pH adjustment are typically achieved at the treatment plant of the wholesale system. Controlling the water temperature is not a practical option for DBP control. Accordingly, the Stage 2 DBPR identifies two BATs for consecutive systems to reduce DBP formation:

- For systems serving fewer than 10,000 people: hydraulic flow and storage management to control and reduce water age.

- For systems serving at least 10,000 people: chloramination with hydraulic flow and storage management.

These options are discussed further in sections 4.2 and 4.3.

Consecutive systems should consult their purchasing agreement with their wholesaler before making modifications to reduce distribution system DBP concentrations. Purchasing agreements may prevent the consecutive system from adding treatment chemicals or making other system modifications. If so, the consecutive system may need to renegotiate its purchasing agreement to add ammonia to convert free chlorine to chloramines. Purchasing agreements may also assign responsibility for such modifications to the wholesaler.

## 4.2 Water Age Management

Water age is a significant factor in DBP formation. As water travels through the distribution system, chlorine continues to react with NOM to form DBPs. The longer the travel time or water age, the more likely it is that water quality will degrade and exhibit higher TTHM and HAA5 concentrations, reduced levels of residual chlorine, reduced effectiveness of chlorine residual through formation of organochlorine compounds, increased microbial activity, nitrification, and/or taste and odor problems. Where high water age is considered to be a contributing factor to elevated DBP concentrations, consecutive systems might consider adoption of operational practices to reduce water age in finished water storage facilities and distribution system piping.

Some of the methods to reduce water age by hydraulic flow and storage management include:

- Pipe looping,
- Managing valves,
- Bypassing oversized pipes,
- Installing dedicated transmission main,
- Improving tank mixing and turnover,
- Eliminating excess storage and tanks in series, and
- Reducing the age of water delivered from the wholesale system, if a dedicated transmission main is not already used.

These methods to reduce water age are discussed below. Additional information about reducing water age in a distribution system can be found in the *Operational Evaluation Guidance Manual* (*USEPA, N.d.*).

### 4.2.1 Pipe Looping

The highest DBP concentrations in a distribution system are most often observed at dead-ends (although this may not be true for HAAs because of biodegradation). Water at dead-ends is often stagnant and therefore provides long contact times for DBP formation. Excessive hydraulic residence time at dead ends can be reduced with pipe looping, which involves constructing new pipe sections to make appropriate hydraulic connections among existing pipes. Pipe looping may not always eliminate water age problems. For example, if two distribution pipes with low demand are looped together and there is insufficient demand to cause water to circulate, then an even larger hydraulic dead-end may result. This may create an even larger area in the system that is subject to water quality problems resulting from high water age, such as high DBP concentrations. Therefore, the specific hydraulic response of a system to looping should be assessed to make sure that looping does not negatively impact the residence time of other parts of the system. Further information on pipe looping can be found in the book *Comprehensive Water Distribution Systems Analysis Handbook* published by AWWA (Boulos, Lansey and Karney 2006).

### 4.2.2 Managing Valves

Intentional or unintentional closed valves in a distribution system may create stagnant water leading to high DBP levels in those locations. The presence of unintentional closed valves could be due to some valves being inadvertently turned in the wrong direction or being broken. These valves may remain undetected due to poor record keeping or because the valve boxes are buried or paved-over. A comprehensive valve inventory and maintenance program can help systems locate valves, determine their status, and find improperly positioned and broken valves.

### 4.2.3 Bypassing Oversized Pipes

In portions of a distribution system where pipes are oversized, the water velocity is lower and therefore hydraulic residence times are longer than necessary, causing high DBP levels. Areas of a distribution system that have been abandoned or have experienced negative demand growth over many years may contain oversized pipes, causing excessive hydraulic residence time. Where appropriate, the pipe sizes in these areas can be reduced or sections of pipes can be valved off if they are no longer needed to reduce the residence time of water. However, the effect of bypassing or valving oversized pipes on downstream areas should be evaluated to make sure that such modifications will not cause hydraulic constrictions for the downstream areas.

### 4.2.4 Installing Dedicated Transmission Main

When water travels through low demand areas and finished water storage facilities in a distribution system before reaching a consecutive system, the water at the entry point to the consecutive system may have high DBP levels due to high water age. In such cases, the installation of a dedicated transmission main to supply water to the consecutive system can be considered to reduce water age but its effects on water age in the wholesale system should be estimated.

### 4.2.5 Improving Tank Mixing and Turnover

Excessive hydraulic residence time in distribution storage tanks results in high water age, which can cause high DBP levels in the tank and at downstream locations in the distribution system. The average hydraulic residence time in a tank can be estimated by the following equation:

$$\text{Theoretical average hydraulic residence time} = [V_{max}/(V_{max} - V_{min})]/N$$

where $V_{min}$ = average minimum daily volume
$V_{max}$ = average maximum daily volume
N = number of drain/fill cycles per day
(Units for $V_{max}$ and $V_{min}$ must be consistent)

It is important to recognize that the above equation provides information about the ***average*** amount of time spent by water inside a tank. In poorly mixed storage tanks, water age may actually be much higher (or lower) than the average hydraulic residence time in some portions of the tank. The $V_{max}$ and $V_{min}$ values are numbers that are averaged from data collected over several days or weeks to represent the typical operational characteristics of the tank. If tank operations are changed from one season to another, then the $V_{max}$ and $V_{min}$ values may be different during different seasons. Typically, the average hydraulic residence time for a storage tank should not exceed 5 days (Kirmeyer et al., 1999). However, some systems may need much lower hydraulic residence times due to site-specific water quality constraints.

The average hydraulic residence time in a storage tank can be reduced by increasing the volume turnover. The volume turnover can be increased by increasing the volume of water that flows in and out of a tank during a given fill/drain cycle (the drawdown), or by increasing the number of fill/drain cycles per day. When possible, the recommended approach is to increase the drawdown between fill cycles. Increasing the number of fill/drain cycles is only effective when 1) the tank is well-mixed at the end of each fill cycle and 2) the drawdown between each fill/drain cycle is equal to the original drawdown. Increasing turnover by either of these strategies may be limited by system hydraulic (pressure) constraints. It may be necessary to adjust tank water level controls or the control settings for altitude valves to increase turnover.

Improving storage tank mixing characteristics can reduce average water age and minimize stagnant zones in the tank. These stagnant zones often have higher water age and thus tend to have higher DBP concentrations. Several tools can be employed to predict water mixing characteristics of a tank:

- Desktop evaluations of hydraulic residence time, fill time, and inlet momentum.
- Computational fluid dynamic (CFD) modeling.
- Temperature measurements.
- Disinfectant residual measurements.

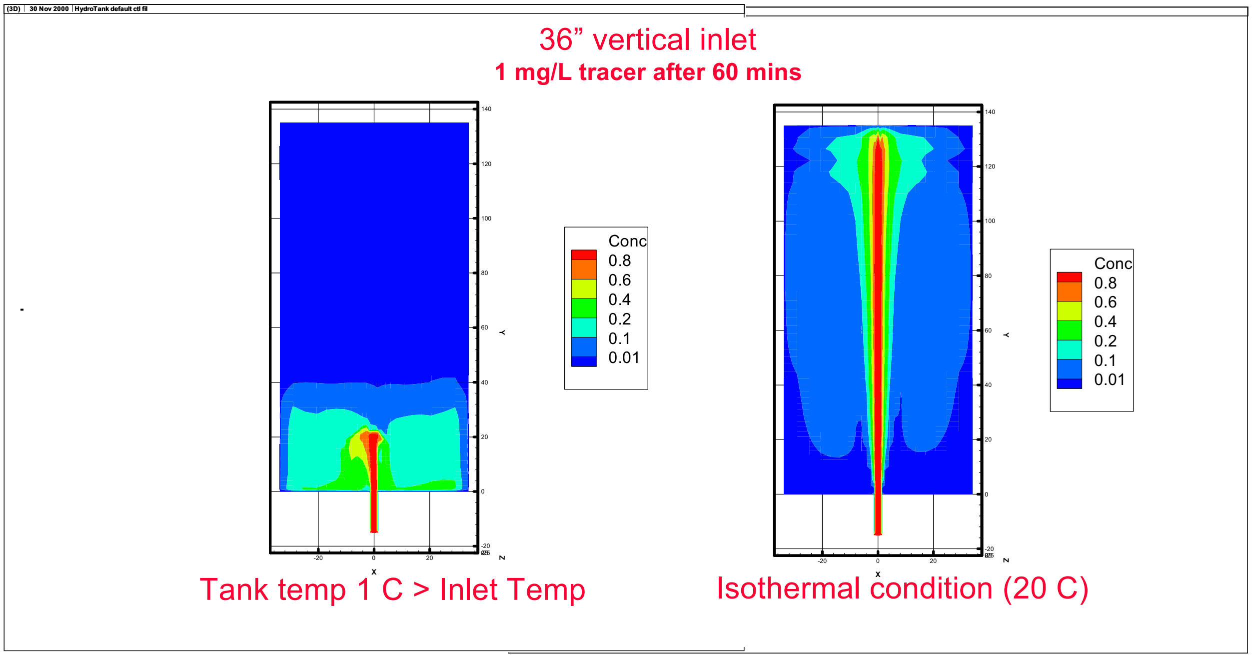
The mixing predictions from desktop evaluations, CFD modeling, temperature measurements, and disinfectant residual measurements can be used to identify a storage tank with inadequate mixing and, therefore, a potential for high DBP formation in some regions in the tank. A method to estimate hydraulic residence time in a tank was presented previously in this section. Fill time and inlet momentum can be estimated from operational records and SCADA data. Generally, longer fill times and greater inlet momentum result in better tank mixing. The minimum acceptable hydraulic residence time and inlet momentum is tank- and situation-specific, and depends on a number of system factors, including water quality, tank geometry, inflow rate, and inlet/outlet pipe configuration.

CFD modeling provides a qualitative description of mixing characteristics by providing visual images of mixing inside a tank. It can be used to determine the effects of fill time and inlet momentum on mixing characteristics.

Poor mixing conditions can cause thermal stratification in a tank. Thermal stratification in turn can exacerbate the poor mixing condition. Depending on the location and orientation of the inlet pipe and tank geometry, the water entering a tank from buried pipes may be cooler than the bulk water in the tank during the summer or warmer than the bulk water in the tank during the winter. In a tank with poor mixing characteristics, colder, denser water remains in the lower portion of the tank, whereas the warmer, less dense water has a tendency to rise to the top of the tank. Water temperature profiles can be used to determine the existence of thermal stratification inside a tank. The temperature profiles can be obtained from the collection of continuous water temperature measurements at various locations in the tank over the course of several days. Temperature differences as low as 1°C between the top and bottom of a tank may indicate a thermally stratified tank with poor mixing.

Exhibit 4.1 shows cross-section views of water mixing characteristics observed in a standpipe tank under slightly different temperature conditions. In this test, a solution containing a one milligram per liter concentration of dye was added to water flowing into the tank. The dye concentrations in the tank were then monitored for a one-hour period. The left-hand profile shows the tank with a bulk water temperature 1º C warmer than the temperature of incoming water. Note that the incoming, colder water remains in the lower portion of the tank. This water will be the first to exit as demand draws water from the tank. The right-hand profile shows much improved mixing when the inflow water and the tank water were at the same temperature.

**Exhibit 4.1 Effect of Temperature Differential Between Inflow and Tank Bulk Water on Mixing Characteristics**




Disinfectant residual measurements, collected either as grab samples or from continuous online monitoring at various locations in the tank, can also be used to evaluate mixing and identify water quality stratification. Acceptable differences in disinfectant residuals within a tank is location-specific and depends on the system water quality. However, the minimum residual should be sufficient to minimize microbial growth and water quality degradation.

Additional information about the use of desktop evaluations, CFD modeling, temperature measurements, and disinfectant residual measurements to evaluate water mixing characteristics in storage tanks, and operational and/or physical modifications to improve mixing characteristics is presented in *Water Quality Modeling of Distribution System Storage Facilities* (Grayman et al., 2000) and *Evaluation of Water Mixing Characteristics in Distribution System Storage Tanks* (Mahmood et al., 2005).

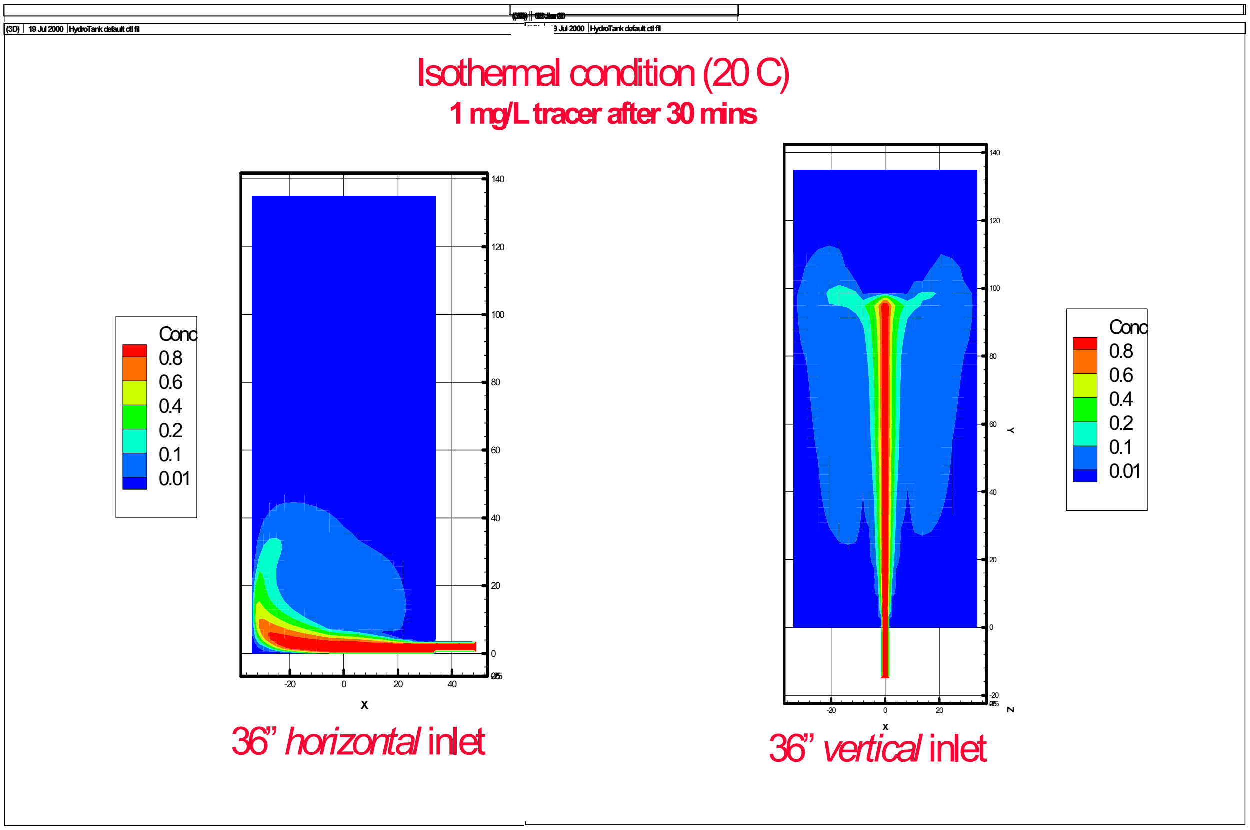
Once the water mixing characteristics of a storage tank have been evaluated, appropriate operational and/or physical modifications can then be recommended to improve water mixing in the tank. The mixing characteristics can be improved by operational changes, which include filling a tank for a longer time period and increasing inlet momentum. If operational changes are not possible, then the mixing characteristics can also be improved by design modifications, such as changing the location, orientation, and/or diameter of inlet/outlet pipes.

Inlet momentum (defined as velocity × flow rate) is a key factor for mixing water in a storage tank. As the inlet momentum increases, the mixing characteristics in the tank improve. The inlet momentum can be increased by increasing the flow rate (which also has the desirable effect of increasing the velocity), through installation of booster pumps near the tank, or other means. However, increasing the flow rate may not be practical due to the limitations of system hydraulics. For example, distribution system pressure may not be adequate to achieve desirable increases in flow rates, or a pump may not be available at the tank location to increase the pumping rate into the tanks. In such cases, the inlet velocity can be increased by reducing the inlet diameter.

The location and orientation of the inlet pipe relative to the tank walls can have a significant impact on mixing characteristics. As water enters a tank through an inlet pipe, a jet is formed and the water present in the tank is drawn into the jet. This forms circulation patterns that result in mixing. The path of the jet must be long enough to allow the mixing process to develop, and therefore should not be pointed directly towards nearby impediments such as a wall or deflector. For example, in a tall, narrow tank, a horizontal inlet pipe at the bottom of the tank is likely to cause the water jet to hit the vertical wall of the tank, resulting in loss of inlet momentum and poor mixing near the top portion of the tank. In general, outlet pipes are located near the bottom of tank, and relocating the inlet pipe near the top of tank may improve mixing characteristics. However, the system hydraulics should be evaluated to ensure there would be adequate pressure to allow the tank to fill to the desired level. Inlet pipes located near the bottom of a tank can be angled upwards, or multiple inlet pipes can be used to improve mixing conditions in a tank. The optimum inlet pipe location and orientation to obtain good mixing in a tank depends on a number of site-specific factors including tank geometry, inflow rate, and temperature differences between the inflow and the bulk water in the tank. Exhibit 4.2 shows predicted mixing characteristics in tanks with two different inlet pipe orientations based upon the results of CFD modeling. The left-hand profile shows limited mixing in a tank with a horizontal inlet. The right-hand profile shows much improved mixing in a tank with a vertical inlet.

In water treatment plant basins, where contact time is required for disinfection and there is generally simultaneous inflow and outflow, internal baffles are sometimes placed inside the basins to encourage plug flow conditions. However, chlorine contact time is usually not an issue in distribution system tanks and reservoirs and baffles should generally be avoided. Baffles encourage plug flow conditions and can result in poor mixing zones (dead zones). Consequently, baffled tanks are likely to experience more significant disinfectant residual decay than tanks with mixed flow conditions. Furthermore, dead zones within baffled tanks can have higher water age and therefore higher DBP concentrations. There may be special circumstances, such as separate inlet and outlet pipes in close proximity to each other, under which a baffle wall may be desirable to force water into other parts of the tank. However, because of the wide variations in tank geometry and inlet/outlet piping configurations for storage tanks, the use of baffles should be carefully evaluated for each specific situation to determine if baffles have any beneficial impact. Tracer testing, CFD modeling, and disinfectant residual monitoring are useful tools to determine the effects of baffles, and to optimize the location, and orientation of the inlet/outlet pipes.

## Exhibit 4.2 Effect of Inlet Pipe Orientation on Mixing Characteristics




### 4.2.6 Eliminating Excess Storage and Tanks in Series

Historically, distribution system storage tanks have generally been built to provide adequate pressures, fire flows, and to meet peak demands. Tanks are also often designed to accommodate future growth and long-term water system needs. Therefore, some distribution system storage tanks may be oversized. Storage tanks may also be hydraulically isolated from the distribution system due to high system pressures, low system demands, or inadequate tank height. Oversized tanks and/or tanks that are hydraulically locked out (due to system pressure being higher than the maximum water level in the tank most of the time) may not have adequate volume turnover, resulting in high water age and high DBP formation potential. When events such as main breaks, fire flows, or other unexpected peak demand conditions occur in a system, water from these tanks may be drawn into the distribution system. Areas receiving water from these tanks may have higher than normal DBP levels.

There are limited options for improving mixing characteristics and reducing water age for a tank that is oversized or hydraulically isolated under normal system operating conditions. It may be possible to increase volume turnover in a tank that is hydraulically isolated if the operational hydraulic grade in the vicinity of that tank can be lowered. This may be accomplished by valving off pipe sections during certain hours so that water demand in the vicinity of the tank is supplied primarily by the tank rather than from other parts of the distribution system. More water can be forced in and out of an oversized tank on a daily basis by installing pumps, adjusting pumping schedules (if pumps already exist), or adjusting the control settings for altitude valves. However these modifications may not be feasible due to system hydraulic limitations. In such cases, decommissioning of the tank can be considered. If a consecutive system has such a tank, and the wholesale system has another tank in the vicinity with adequate storage, then the consecutive system tank may be able to decommission its tank. However, coordination with the wholesale system is necessary to ensure that when the consecutive system's tank is decommissioned, the wholesale system's tank has adequate hydraulic capacity (both storage and piping) for equalization storage, fire flow, or emergency conditions such as main breaks. Refer to Chapter 6 for additional information about communicating with the wholesale system.

Tanks in series can also lead to high DBP levels in areas downstream of the tanks if there is inadequate mixing and volume turnover in the tanks. If the mixing and volume turnover issues cannot be addressed, consideration should be given to whether water can be re-routed to the distribution system pipe network directly rather than through other tank(s). Re-routing the water flows will involve adjusting valve positions in the pipe network and pumping set points and schedules. A system operational analysis (generally using a hydraulic model) will be needed to determine the pressure and flow impacts caused by re-routing the water flow. Elimination of tanks in series may reduce the volume turnover in these tanks due to associated changes in frequency and magnitude of the drain/fill cycles; therefore, these impacts need to be evaluated.

## 4.3 Reduction of Disinfectant Demand

Aging pipes such as unlined cast iron pipes exert high disinfectant demand because of the presence of corrosion byproducts, biofilms, and sediment deposits. Consecutive systems can reduce localized chlorine decay and thus reduce the overall disinfectant demand by replacing or cleaning and lining pipes, and/or by conducting periodic flushing.

### 4.3.1 Replacing or Cleaning and Lining Unlined Cast Iron Pipes

Pipe replacement may be the preferred option for reducing disinfectant demand if a pipeline has structural problems or if there is a need to increase hydraulic capacity with a larger diameter pipe. If a pipeline is structurally sound, then pipe cleaning is a less expensive option. For unlined cast iron pipes, pipe lining may also be necessary to achieve a permanent improvement and prevent a recurrence of the disinfectant demand problem. The AWWA Standard, *Rehabilitation of Water Mains (M28)*, $2^{nd}$ Ed. (AWWA 2001), provides information and guidance on cleaning and lining technologies.

### 4.3.2 Distribution System Flushing

Periodic flushing can be an effective tool to control TTHM and HAA5 peaks to remove pipe sediments and biofilms, thereby reducing disinfectant demand. There are several approaches to conducting distribution system flushing depending on system configuration and water quality goals. The AwwARF report, *Guidance Manual for Maintaining Distribution System Water Quality* (Kirmeyer et al. 2000) provides detailed information on various flushing approaches. Regardless of the flushing method implemented, utilities should use water quality data to identify periods when DBPs have historically been high. However, utilities cannot simply flush in the area where DBP samples are collected prior to sampling dates for the purposes of reducing DBP compliance monitoring results. This practice is not allowed because such intermittent flushing is not considered normal operations.

Conventional flushing is considered routine distribution system maintenance and is conducted by opening hydrants without directing the flow through the distribution system with isolation valves. Fire hydrants are usually opened and allowed to run until the water clears. While utilities often move through the system sequentially when practicing conventional flushing, this should not be confused with directional flushing. The velocities used for conventional flushing may be inadequate (less than 5 feet/second) for removing sediment, corrosion byproducts, and other debris that can contribute to high DBP levels. It is also possible to draw dirty water from other areas into the areas being flushed. Additional information on flushing practices and selection of flushing velocities can be found in the AwwaRF report, *Establishing Site-Specific Flushing Velocities* (Friedman et al. 2003).

Directional flushing involves the flushing of water in one direction through systematic operation of distribution system valves. Utilities practicing directional flushing typically begin at a source of clean water (e.g., a large transmission main) and systematically move through the system opening hydrants and manipulating system valves to assure water moves in only one direction through the system. Because water travels toward a hydrant in a single direction, higher flushing velocities can be achieved. A properly designed and implemented directional flushing program can achieve water velocities higher than 5 feet/second to scour the pipe. In addition to increasing water flow in the selected main, directional flushing can reduce the impact of other factors contributing to the formation of high DBP concentrations including the accumulation of sediments and the build-up of corrosion byproducts. (Joseph and Pimblett, 2000)

"Blow-offs" can be used to eliminate dead-ends and stagnant water zones that have high water age and therefore contribute to high DBP levels. Blow-offs can operate in an automatic intermittent mode or continuous mode to remove old water from dead-end or stagnant zones and pull fresher water into these locations from other areas. The velocities for a blow-off are generally insufficient (< 2.5 feet/second) to remove sediments or biofilm. Blow-offs can be used on a seasonal basis when DBP peaks are more likely to occur, such as during high water temperature periods. The need for and appropriate locations for blow-offs can be determined from distribution system flow models or distribution system historical records. Low disinfectant residuals, high DBP concentrations, high heterotrophic plate counts (HPCs), coliform-positive samples, or nuisance bacteria are often associated with high water age locations.

Whenever flushing is used, it may be necessary to dechlorinate or dechloraminate flushing water to prevent adverse impacts on nearby streams. Both chlorine and chloramines can have negative impacts on aquatic environments. Depending on where flushed water is discharged, it may end up in nearby streams or other bodies of water. In such cases, a dechlorinating agent (e.g., sodium bisulfite or sodium thiosulfate) can be used to prevent fish kills or other adverse effects. Consult your State or local regulatory agency to determine if it is necessary to dechlorinate or dechloraminate flushing discharges. Also consider discharging the flushed water to the sewer system.

## 4.4 Chloramination

As identified in Section 4.1, the disinfectant type can be a significant factor in DBP formation. Where the use of free chlorine is considered to be a contributing factor to elevated DBP concentrations, consecutive systems might consider switching to chloramines for secondary disinfection. THM and HAA formation is generally significantly lower for chloramines than for free chlorine. However, consecutive systems should consider the following issues before switching from free chlorine to chloramines:

- Water quality issues for chloramines such as the formation of other currently unregulated DBPs, nitrification, corrosion, and taste and odor issues.
- Whether to switch all or only a portion of the distribution system to chloramines.
- Cost, handling, and safety issues.

These issues are discussed further in the following sections. Additional information on chloramination can be found in EPA's *Simultaneous Compliance Guidance Manual for the Long Term 2 and Stage 2 DBP Rules* (USEPA, 2007a)

### 4.4.1 Water Quality Issues for Chloramines

Chloramines are an effective secondary disinfectant because they are generally less reactive than free chlorine causing them to be more persistent in the distribution system and are able to better penetrate biofilms. This greater persistence allows some utilities (e.g., large systems in warm water climates), who would otherwise be unable to maintain a disinfectant residual using free chlorine, to maintain a residual in the distribution system. In addition, the concentrations of TTHM and HAA5 usually decrease when switching from free chlorine to chloramines. Chloramines can react with organic precursor material to form THMs, but the reaction rates are very slow compared to free chlorine. Chloramines are highly effective at reducing THM formation levels in the distribution system and the reduction in THM levels is generally 40 to 80 percent compared to free chlorine. Chloramines also produce lower levels of HAAs than free chlorine, but may not be effective in controlling all types of HAAs. Some brominated HAAs are formed with chloramines. Chloramines generally produce lower levels of total chlorinated byproducts than free chlorine.

Potential operational and simultaneous compliance issues when using chloramines include the following:

- Nitrification,
- Increased corrosion and metal release,
- Taste and odor issues,
- Weaker disinfectant,

- Blending issues – chloraminated and chlorinated waters,

- Safety concerns,

- Issues with ozonation and GAC filtration, and

- Issues for dialysis patients, fish owners and industrial customers.

The reader is referred to EPA's *Simultaneous Compliance Guidance Manual for the Long Term 2 and Stage 2 DBP Rules* (USEPA, 2007a) for more detailed information on these issues.

### 4.4.2 Options for Chloramine Conversion

When the wholesaler uses free chlorine for secondary disinfection and the consecutive system switches to chloramines for secondary disinfection of the water it provides, the consecutive system has two options for managing their water with disinfectants:

- Option 1: Convert part of the consecutive system's distribution system to chloramines and physically separate that area from the wholesaler's and other areas of the consecutive system's distribution systems.

- Option 2: Convert the consecutive system's entire distribution system to chloramines and physically separate the system from the wholesaler's system.

*Option 1*

The first option may be considered if the consecutive system only needs to reduce high DBP levels in specific areas. Depending on the hydraulic characteristics of the distribution system, it may be feasible to isolate the chlorinated water from the chloraminated water in the same way that different pressure zones are isolated. The separation of the waters in the distribution system can be an inexpensive solution if it only involves closing a few existing valves or if it requires the installation of only a few new valves. If the chloraminated portion of the distribution system is connected to the chlorinated portion of the system with only a few major pipes, rather than a maze of small mains, then the physical separation of the waters would be an attractive solution.

Caution should be exercised when considering conversion of only a portion of the system to chloramines. The physical separation of areas of the distribution system may reduce the reliability of the water supply to some service areas. The separation could lead to reduced fire-flow capacity and reduced pressure in some areas. The dynamics of water flow may also change to prevent adequate turnover in storage tanks. Flow reversal might also occur and could lead to water quality problems.

*Option 2*

The second option is more appropriate if the consecutive system desires reduction of DBP levels throughout its distribution system. Depending on the wholesale system-consecutive system interconnections, converting the entire distribution system to chloramines might minimize the hydraulic separation issues. It may also prevent potential water quality problems that would have resulted had the chlorinated and chloraminated water blended in the consecutive distribution system due to valve failure between pressure zones. Conversion of the entire distribution system from free chlorine to chloramines will require larger or additional ammonia and chlorine storage and feed systems. The ammonia feed system would have to be installed at the point-of-entry to the consecutive system such that the chlorine is converted to chloramines prior to entering the distribution system. Systems should consider installing backflow prevention devices or other control features at the interconnections between the wholesaler and consecutive systems to ensure that chloraminated water from the consecutive system does not backflow into the wholesaler's system and mix with the wholesaler's chlorinated water.

Prior to conversion of all or a portion of the consecutive system to chloramines, the consecutive system should contact the State to determine what additional operational or other requirements apply. Many consecutive systems may not employ certified water treatment plant operators. Depending on the State, the addition of chemical feed facilities may constitute treatment and require the system to employ full- or part-time certified water treatment plant operators.

### 4.4.3 Cost, Handling, and Safety Issues

Conversion of chlorinated water to chloraminated water requires the addition of ammonia. Ammonia can be added in the form of anhydrous ammonia, aqueous ammonia, or ammonium sulfate. Each system needs to determine the most appropriate type of chemical to use by evaluating factors such as chemical cost, safety, storage requirements, and ease of handling. Ammonia costs in the United States vary considerably. Anhydrous ammonia is generally the least expensive option, followed by aqueous ammonia, and then ammonium sulfate. Considerations related to the use of these chemicals are discussed in *Optimizing Chloramine Treatment*, *First and Second Editions* (Kirmeyer et al., 1993 and 2004).

The chemical feed systems for chlorine and ammonia must be capable of injecting the prescribed chemical doses into the water. Accurate feed control is necessary to ensure that a consistent desired chlorine to ammonia ratio (generally in the range of 4.5:1 to 5:1) is maintained. Immediate adjustments to chlorine or ammonia feed rates are necessary in response to changes in flow rates or other variables. These adjustments can be made automatically with feedback systems such as flow pacing or compound loop control. In a flow pacing system, the dose depends on the flow rate, which can be measured by a flow meter. This type of feed control can work if the chlorine residual entering the consecutive system is consistent. When both the flow rate and the chlorine residual vary, a compound loop control system is needed to adjust the chemical doses based on the flow rate and the chlorine residual. In this case, a flow meter measures the flow rate and a chlorine analyzer measures the chlorine residual, and both signals are sent to a controller. The controller integrates the two signals and sends a signal to adjust the chemical doses. Many variations of the compound loop control system are available commercially.

### 4.4.4 Public Education

Before converting from free chlorine to chloramines as the secondary disinfectant, customer concerns should be addressed through public education and notification. Customer concerns generally fall into one of two categories:

- Human health concerns. Chloramines are toxic to kidney dialysis patients. Each hospital and dialysis treatment center should be advised before a conversion is made so they can provide adequate testing and treatment.

- Miscellaneous household concerns. Chloramines (and chlorine) are generally toxic to fish, so homeowners, pet stores, and related businesses should be contacted.

Each PWS should prepare a public education plan prior to a conversion to chloramines. Public education information, including examples of public education materials, can be obtained from *A Guide for the Implementation and Use of Chloramines* (Harms and Owen, 2004). PWSs may also want to add relevant language to their CCRs to keep customers advised of the presence of chloramines in their drinking water.

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# 5.0 Other Alternatives for Consecutive Systems

The BAT options identified by the Stage 2 DBPR for consecutive systems to reduce DBP levels are presented in Chapter 4. This chapter presents some of the other alternatives available for consecutive systems to reduce distribution system DBPs and achieve compliance with the requirements of the Stage 2 DBPR. The alternatives discussed in this chapter are (1) improving water quality from a wholesale system by methods such as treatment changes, reducing hydraulic residence time, and booster disinfection; and (2) finding alternative sources of water with higher quality and blending with wholesaler's water either at the treatment plant or in the distribution system. This chapter is divided as follows:



## 5.1 Improved Water Quality from the Wholesale System

The finished water leaving a wholesale system's treatment plant can spend a considerable amount of time in the distribution system pipes before reaching a consecutive system. High hydraulic residence time combined with a sufficient disinfectant dose to maintain adequate disinfectant residual throughout the distribution systems can lead to high DBP formation in the consecutive system. For a consecutive system that uses free chlorine for secondary disinfection, the increase in DBP concentrations in the distribution system may be significant. If a consecutive system is unable to effectively reduce DBPs in its system because of the levels in the purchased water, the consecutive system should consider discussing control strategies with the wholesale system. Refer to Chapter 6 for additional information about communicating with the wholesale system.

Some DBP control strategies that a wholesale system can implement include:

- Achieving better DBP precursor removal at the treatment plant by optimizing coagulation and/or clarification processes, or by adding a new treatment step such as GAC filtration or nanofiltration.

- Moving the point of primary disinfectant addition downstream after removal of more DBP precursors.

- Using an alternative primary disinfectant (e.g. ozone, chlorine dioxide) and/or secondary disinfectant.

- Reducing disinfectant demand.

- Reducing disinfectant dose.

- Reducing the hydraulic residence time between the wholesale system's treatment plant and the consecutive system.

Chapter 4 discusses options to reduce water age in greater detail. More information on these DBP control strategies can also be found in the following sources:

- *Stage 2 DBPR Operational Evaluation Guidance Manual* (USEPA, N.d.)
- *Enhanced Coagulation and Enhanced Precipitative Softening Guidance Manual* (USEPA, 1999b)
- *Simultaneous Compliance Guidance Manual for the Long Term 2 and Stage 2 DBP Rules* (USEPA, 2007a)

If it is not feasible for the wholesale system to implement some of the DBP control strategies identified above, then the use of booster disinfection systems can help reduce DBP levels. Booster disinfection systems could be installed in areas within the wholesale or consecutive system where it is difficult to maintain disinfectant residuals, thereby allowing the wholesale system to reduce the disinfectant residual leaving the treatment plant. Optimizing the location and operation of booster disinfection facilities in the distribution system is important to obtain desired results. The results from hydraulic models, disinfectant residual data, disinfectant decay data, and other water quality data are needed to determine appropriate booster disinfection locations.

The advantages of using booster disinfection facilities include:

- Increasing the disinfectant residual only in areas that require it without increasing the disinfectant residual in other parts of the system beyond acceptable levels.
- Maintaining a more consistent disinfectant residual throughout the distribution system.
- Reducing the disinfectant dose and DBP formation at the treatment plant and prior to the point of booster disinfectant addition.

The disadvantages of using booster disinfection facilities include:

- Difficulty in controlling the required disinfectant dose at multiple booster stations due to the dynamic nature of chlorine demand in the system.
- Regulatory concern with the degradation byproducts if hypochlorite is used or safety issues if chlorine gas is used.
- Booster operation in chloraminated distribution systems can be challenging.

For a chlorinated system, the primary controlling factor for chlorine dose is the difference between the measured and desired free chlorine residual. For the chlorine and ammonia dose in a chloraminated system, there are other controlling factors besides the difference between the measured and desired total chlorine residual, such as excess free ammonia in the system due to chloramine decay. It is important to note that while booster disinfection can lead to lower DBP concentrations entering the consecutive system, it may do little to reduce DBP concentrations at the extremities of the distribution system, particularly where water age is excessive.

## 5.2 Alternative Sources and Blending Strategies

A consecutive system may consider the use of an alternative water source with higher quality for reducing high DBP levels in the system. If high DBP levels in a consecutive system are due to the wholesaler's use of a surface water supply, then the consecutive system can consider using a new groundwater source or increase the use of an existing groundwater source (if available) to supplement the surface water supply from the wholesaler. Groundwater tends to have lower TOC concentrations than surface water and is also less subject to rapid fluctuations in TOC levels that may occur with surface water during periods of heavy runoff. Lower TOC levels can significantly reduce DBP formation at the treatment plant, and for systems that use free chlorine for secondary disinfection, the DBP reduction may also be significant in the distribution system. During the summer, groundwater has lower temperatures than surface water. If a disinfectant is added at the treatment plant shortly after groundwater is withdrawn from the ground, then lower temperatures can reduce DBP formation at the treatment plant.

Increasing groundwater use or finding new groundwater sources may be difficult because excessive groundwater withdrawal can reduce the groundwater table below desirable levels. This may result in degraded groundwater quality and may affect stream flow levels. Sustainable use of groundwater as an alternative source will require careful planning to allow adequate time for groundwater recharge.

Another option for a consecutive system to reduce high DBP levels is to obtain an alternative water source by purchasing water from another adjacent utility if the utility can offer higher quality water. This option may be economically feasible if the water supply from the other utility is in close proximity to the consecutive system. Generally, when the availability of higher quality water is limited, the consecutive system may deliver the higher quality water only to parts of the distribution system that have high DBP levels. Interconnections between the two systems, and new pipelines, valves, and pumps may be required to deliver the higher quality water to the desired areas.

When two or more alternative water sources are mixed, the final characteristics of the blended water depends on the water quality characteristics of the individual sources and the blending ratios. For DBP control, the primary water quality characteristics of concern are the types and concentrations of disinfectants and DBP precursor concentrations (such as TOC) present in each source. In many cases, blending may minimize the formation of high DBP levels, but other water quality problems may actually increase. Therefore, other water quality characteristics such as corrosion potential, pH, taste, loss of disinfectant residual, and hardness also need to be considered. Examples of water quality problems due to improper blending ratios of alternative sources include:

- Loss of disinfectant residual when blending chlorinated and chloraminated water;

- Increases in taste and odor;

- Increased corrosivity or increased calcium carbonate precipitation due to changes in pH, alkalinity, and hardness;

- Iron and manganese precipitation due to water in a reduced state (groundwater) mixing with water in a higher oxidized state (surface water); and

- Continual changes in chemical reactions between pipe walls and blended water due to intermittent flow reversals when the mixing zone of alternative water sources moves in relation to variable water demands in the system.

Systems considering blending or making changes to their blending ratios should consider first performing a blending analysis to determine the effects of blending the different water sources. Blending analyses can be performed with hydraulic models, water quality models, or bench scale tests. Hydraulic modeling can be used to predict the areas of the system primarily supplied by each source and the areas where mixing of two or more sources takes place. Mixing zones and the relative contribution of each source at a given location can be predicted. The changes in the locations of mixing zones due to varying water demands can also be predicted. Water quality modeling can be used to predict water age, disinfectant residual, and DBP levels. Even if changes in water quality can be predicted from water quality models and spreadsheets, water quality monitoring is necessary to verify the effects of blending.

It is generally easier to blend alternative sources before they enter the distribution system, especially if the blended water can be treated to the desired quality. However, if a wholesale system's treatment plant is far from the alternative water source, and the high DBP areas of a consecutive system are in close proximity to the alternative source, then it may be more feasible to introduce the alternative source to the affected part of the system directly through interconnections.

If water quality problems arise when water is blended in the distribution system, systems may consider physical or hydraulic separation of the different waters in the distribution system using valves and additional piping. The physical separation of portions of a distribution system may reduce water supply reliability, fire-flow capacity, and pressure in some areas. Detailed distribution system studies are helpful to determine the impacts of physical separation.

# 6.0 Communication Strategies for Consecutive and Wholesale Systems

Consecutive systems and wholesale/consecutive system interactions and contractual relationships can be complex. To improve compliance with the requirements of the Stage 2 DBPR, consecutive systems can utilize effective communication strategies with the wholesale system. It is important to establish a communication process for the consecutive systems to be aware of water quality and operational issues in the wholesale systems. Communication approaches could include:

- Dedicated phone lines with afterhours forwarding or recorded message capacity;
- Web-based information pages and message posting;
- Pager and cell phone message transmission;
- E-mail notification; and
- Laboratory notification to both the consecutive and wholesale system.

For information on communication strategies for IDSEs, refer to Appendix A of the *Stage 2 DBPR Initial Distribution System Evaluation Guidance Manual* (USEPA, 2006).

This chapter is organized as follows:

6.1 Communication Strategies for Stage 2 DBPR Compliance Monitoring
6.2 Communication Strategies for Operational Evaluations
6.3 Agreements Between Consecutive and Wholesale Systems

## 6.1 Communication Strategies for Stage 2 DBPR Compliance Monitoring

This section provides recommended communication strategies for consecutive and wholesale systems related to Stage 2 DBPR compliance monitoring. Stage 2 DBPR compliance monitoring requirements for consecutive systems vary by source water type and system size. Chapter 3 discusses Stage 2 DBPR compliance monitoring requirements in greater detail.

Before beginning Stage 2 DBPR compliance monitoring, each system must prepare a subpart V monitoring plan. Consecutive and wholesale systems should work together to coordinate their Stage 2 DBPR compliance monitoring schedules and should provide copies of their final subpart V monitoring plans to one another. It is not necessary for each consecutive system in a combined distribution system to provide copies of their monitoring plans to each other, but each consecutive system should provide a copy to the wholesale system, and each consecutive system should request a copy of the wholesale system's monitoring plan. Where a consecutive system receives water through another consecutive system, the second consecutive system should request a copy of both the first consecutive system's and the wholesale system's monitoring plan.

Although not required by the Stage 2 DBPR, coordination of compliance monitoring will allow both the wholesale and consecutive system to better understand DBP formation across the combined distribution system and help to formulate an appropriate compliance strategy, when necessary. Similarly, coordinating sampling schedules will better enable wholesale and consecutive systems to identify changes in source, treatment, or operation that impact DBP formation in the distribution system. More specifically, coordination of Stage 2 DBPR compliance monitoring schedules will help consecutive and wholesale systems conduct operational evaluations, when required. Recommended communication strategies for operational evaluations are discussed in greater detail in Section 6.3.

To coordinate Stage 2 DBPR compliance monitoring for the wholesale and consecutive systems, their sampling schedules should account for the approximate system water age. For example, if it takes three or four days for water to pass through the consecutive system, the consecutive system might consider sampling three or four days after the wholesale system. When one consecutive system receives water through another consecutive system, the second system should account for the approximate water age in the first system when scheduling monitoring. Exhibits 6.1 and 6.2 show these concepts graphically. Exhibit 6.3 shows an example where a consecutive system receives water from a wholesale system transmission main with a known approximate water age. If approximate water ages at individual sample locations are known more precisely, the consecutive system may schedule monitoring at those locations based on individual location water ages. An example of this approach is provided in Exhibit 6.4. Again, the Stage 2 DBPR does not require wholesale and consecutive systems to coordinate monitoring schedules, and it does not require that monitoring schedules account for water age differences between wholesale and consecutive systems. In fact, in complex distribution systems and systems with limited understanding of hydraulic patterns and water age, such an approach can be difficult to implement. Also, this monitoring approach presented in Exhibit 6.4 may result in higher sampling costs since the consecutive system would be sampling on multiple days.

**Exhibit 6.1 Coordinating Stage 2 DBPR Compliance Monitoring Schedules - Consecutive System Receiving Water Directly from Wholesale System**

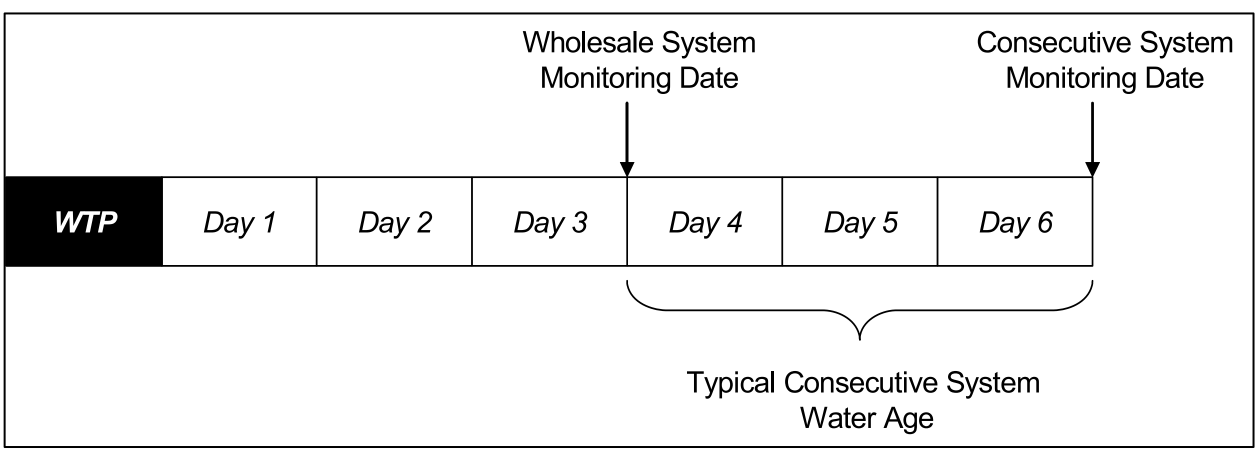


**Exhibit 6.2 Coordinating Stage 2 DBPR Compliance Monitoring Schedules - Consecutive System Receiving Water Through Another Consecutive System**

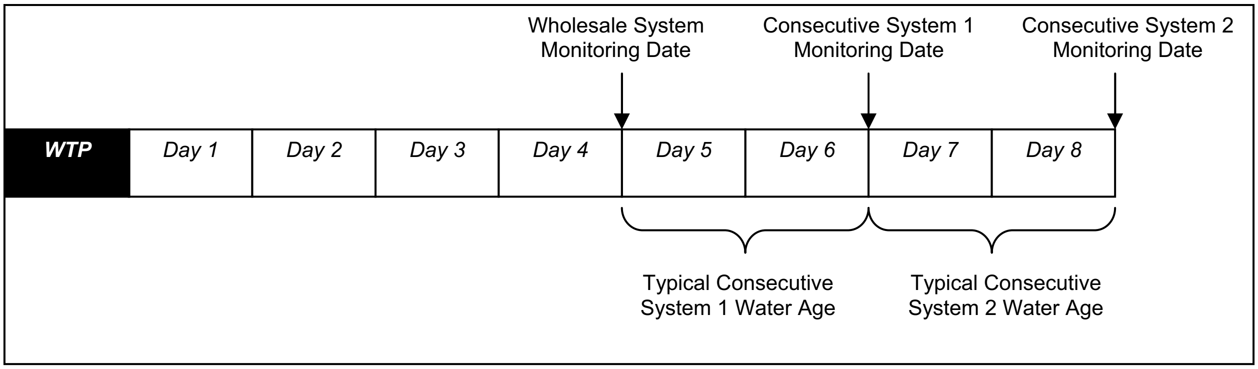



**Exhibit 6.3 Coordinating Stage 2 DBPR Compliance Monitoring Schedules - Consecutive System Receiving Water from Wholesale System with No Customers**

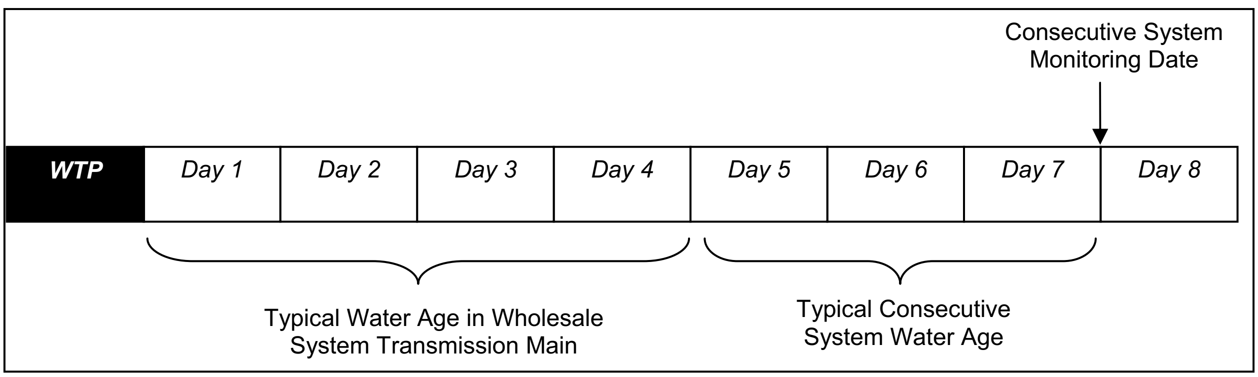
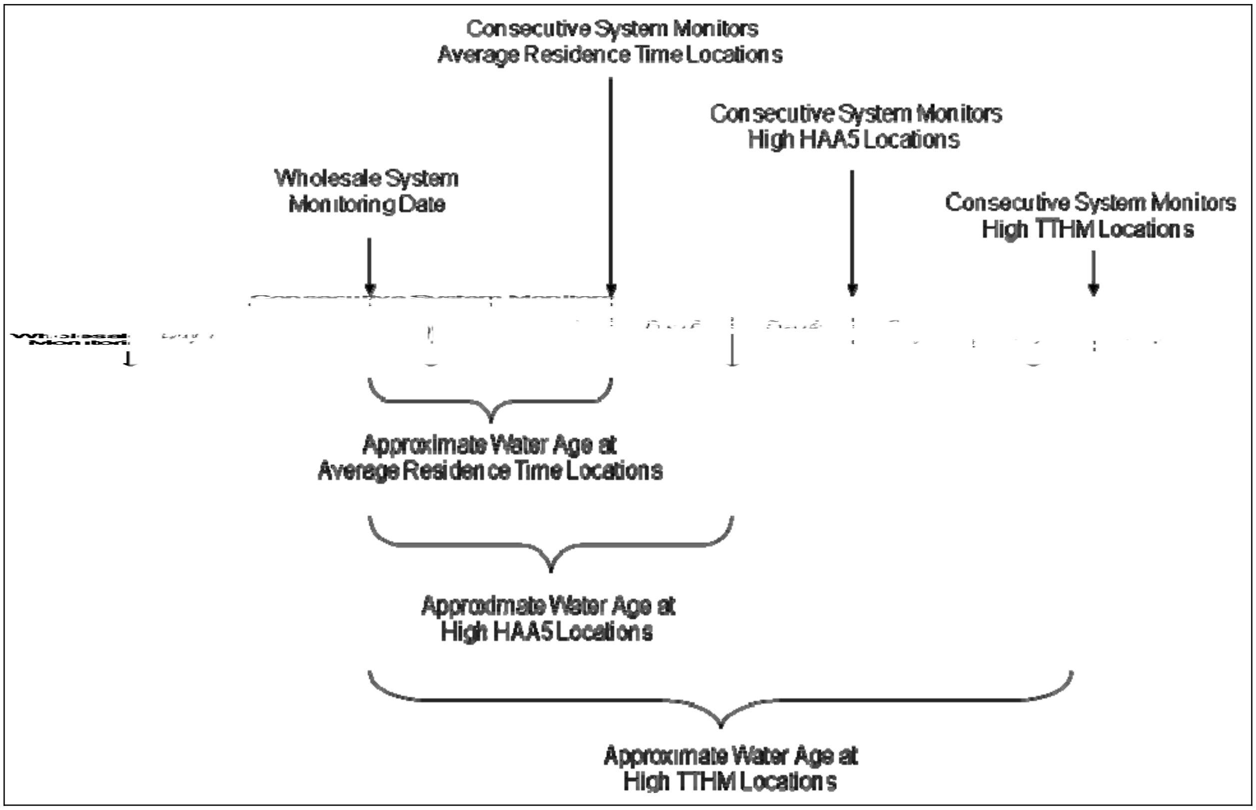


**Exhibit 6.4 Coordinating Stage 2 DBPR Compliance Monitoring Schedules - Approximate Water Age of Monitoring Locations is Known**




Consecutive and wholesale systems should share compliance monitoring data with each other as results are gathered. This will help all parties understand their status relative to Stage 2 DBPR compliance and, hopefully, prevent future surprises in the form of elevated DBP concentrations or LRAAs near the MCLs. Consecutive systems are also encouraged to ask the wholesale system to notify them in the event of any source, treatment, or operational upsets that might impact DBP formation. Similarly, consecutive systems should notify the wholesale system immediately if they encounter unusual water quality data (e.g., changes in chlorine residual or DBP concentrations).

## 6.2 Communication Strategies for Operational Evaluations

This section discusses how communication between consecutive and wholesale systems can be enhanced to either prevent or, when necessary, conduct an operational evaluation. As described in Chapter 3, consecutive systems and wholesale systems are required to conduct an operational evaluation when a routine DBP sample result, if repeated, would result in an exceedance of either the TTHM or HAA5 MCL. For example, the TTHM concentrations for the past four quarters at one of a utility's Stage 2 DBPR monitoring locations are 0.055, 0.065, 0.07, and 0.095 mg/L (LRAA = 0.071 mg/L). The 0.095 mg/L concentration will trigger an operational evaluation, since a repeat value of 0.095 mg/L, resulting in values of 0.065, 0.07, 0.095 and 0.095 mg/L (LRAA = 0.081 mg/L), would result in an exceedance of the TTHM MCL at this location. The *Stage 2 DBPR Operational Evaluation Guidance Manual* (USEPA, N.d.)

provides much greater detail regarding identification of an operational evaluation level exceedance and conducting an operational evaluation.

For consecutive systems, conducting an operational evaluation requires communication with the wholesale provider. Where water is received through another consecutive system, communication between consecutive systems may also be necessary. The wholesale system is most likely to have data regarding source and finished water TOC, disinfectant residual, pH, temperature, and other water quality parameters that impact distribution system DBP concentrations. Further, a comparison of wholesale and consecutive system DBP concentrations may help to identify the cause of the operational evaluation level exceedance. For example, if finished water quality was normal and wholesale system DBP concentrations were in their expected range, the cause of the operational evaluation level exceedance might be attributed to distribution system operations in the consecutive system (e.g., reduced demand contributing to higher water age).

The need for communication between consecutive and wholesale systems when conducting an operational evaluation also underscores the value of coordinating Stage 2 DBPR compliance monitoring schedules. While finished water quality (e.g., TOC, temperature, etc.) may help to identify the cause of an operational evaluation level exceedance, a comparison of consecutive and wholesale system DBP concentrations may also be helpful in terms of how DBP levels change as water moves further from the treated water source.

## 6.3 Agreements between Consecutive and Wholesale Systems

Agreements between consecutive and wholesale systems, both formal and informal, can significantly improve coordination between consecutive and wholesale systems. These agreements establish lines of communication and assign responsibility for water quality in each of the systems. Such agreements can help to create cooperative, working relationships where no prior relationship exists. Where prior relationships exist, such agreements can clarify or enhance existing relationships. In either case, the agreement represents a commitment to protect public health by both the consecutive and wholesale system. Exhibits 6.5 and 6.6 provide case studies of formal and informal agreements, respectively.

## Exhibit 6.5 Case Study of Formal Agreements between Consecutive and Wholesale Systems

Denver Water Department in Colorado serves more than 1 million customers in the City of Denver, Denver County, and surrounding suburban areas. This includes nearly 80 water service contracts with consecutive systems. Under the Colorado Department of Public Health and Environment provisions for *integrated systems*, Denver Water has executed formal agreements with each of these consecutive systems. Under these agreements, Denver Water assumes responsibility for all regulatory compliance monitoring and sample analysis. However, the consecutive system is responsible for maintaining compliance with regulatory requirements.

The Denver system is very complex. In some cases, water passes from one consecutive system to another. In other cases, water may pass through a consecutive system and return to Denver's distribution system. As previously mentioned, Denver has assumed responsibility for all compliance monitoring under their service contracts. The consecutive systems are responsible for meeting all of Denver Water's operating requirements and engineering standards. These requirements dictate that the consecutive systems essentially operate in the same manner as Denver Water, including flushing, storage tank cleaning, backflow prevention, and utilization of certified operators.

*Source:* Lohman, Steve < 303.628.6000, Manager of Water Quality at Denver Water Department>. 2007. Phone Call With Chris Hill of Malcolm Pirnie, Inc. 813.242.7204.

## Exhibit 6.6 Case Study of Informal Agreements between Consecutive and Wholesale Systems

The Cobb County-Marietta Water Authority (the Authority) provides water to 13 consecutive systems in northwestern metropolitan Atlanta, Georgia. These systems include municipal and county water systems, as well as one industrial and one institutional customer. Of these customers, nine are sole-source customers buying their water only from the Authority. The Authority provides water service to its consecutive systems under long-term service contracts up to 50 years in length. These contracts stipulate that the Authority will provide the customer with water at mutually agreeable locations (connections). The contracts include no mention of water quality.

The Authority has no retail customers of its own, and has no contractual obligation other than to "provide water" to its consecutive systems. The contracts also make no mention of sales volume.

The Georgia Environmental Protection Division (EPD) has worked with the Authority and its sole source customers to address water quality on a rule-by-rule basis. The Total Coliform Rule is addressed by each consecutive system individually. The Lead and Copper Rule is administered to the Authority and its sole source customers as a single entity. Under this approach, if one system violates an MCL, then every consecutive system must respond as directed by EPD. A consecutive system can unilaterally withdraw from this arrangement, but must then conduct the monitoring and reporting to EPD individually. The Authority staff meets regularly with its consecutive systems to discuss and address water quality and regulatory issues, and all parties are involved in a cooperative working relationship.

For the Stage 1 DBPR, the Authority and its sole-source customers are considered by the Georgia EPD as a combined distribution system. EPD worked with the Authority in developing the combined system DBP monitoring plan. Under this arrangement, the Authority has responsibility for all DBP monitoring in the combined sole-source distribution system.

In preparation for the IDSE required under the Stage 2 DBPR, the Authority and its sole-source customers jointly conducted a fluoride tracer study to determine the areas of oldest water in the system. The information gathered under this study was used individually by the consecutive systems to develop their IDSE monitoring plans.

*Source:* Parsons, James < 770.426.8788 Director of Engineering, Cobb County-Marietta Water Authority>. 2005. June 9, 2005.

The Colorado Department of Public Health and Environment (the Department) has established requirements for *integrated systems* - which consider the consecutive and wholesale systems as a single regulated entity (5 Colorado Code of Regulations 1003-1). The Department requires that the wholesale and consecutive systems included in the integrated system execute a "...contract, memorandum of agreement, or other enforceable mechanism." The application for consideration as an integrated system includes the following:

- A contact person, address, and phone number for each participating system, and each regulatory requirement for which an integrated system is being created.

- The number of persons served by the wholesale and each consecutive system and whether the consecutive system is providing further disinfection.

- A map showing the supply system and each consecutive system including the relevant elements of the distribution system such as meters, piping, pump stations, storage tanks, and finished water reservoirs.

- A sampling plan for each regulatory provision covered by the integrated system (e.g., DBPs or disinfectant residual monitoring). The sampling plan shall meet all of the requirements of the respective provision and shall also identify the responsibilities of each party.

- A copy of each agreement between the consecutive and wholesale systems, including a common set of operations and maintenance standards that the wholesale system has established for each regulatory requirement for which an integrated system is being created.

- A statement that clearly assigns legal responsibility to one of the participating systems for compliance with each individual regulatory provision in the integrated system.

An example of a formal agreement meeting the requirements of the State of Colorado is provided in Appendix A. Other States may have specific requirements that must be met in preparing these agreements. Water systems should contact their State to determine how specific requirements apply to wholesale and consecutive systems.

Regularly scheduled communication between consecutive and wholesale systems can be an effective tool for managing water quality. Weekly, biweekly, monthly, or even quarterly meetings between a consecutive system and its wholesale provider are an appropriate forum to discuss and address water quality concerns. Where multiple consecutive systems purchase water from a wholesale system, meetings that involve all of the consecutive systems in the combined distribution system are recommended.

# 7.0 Developing Consecutive System Compliance Strategies

The Stage 2 DBPR specifically requires consecutive systems to comply with the same MCLs for DBPs as wholesale systems and extends the disinfectant residual and MRDL requirements of the Stage 1 DBPR to consecutive systems. Chapter 3 discusses these requirements and their impacts on consecutive systems in greater detail. This chapter discusses a methodology that can be employed by consecutive systems to develop a compliance strategy to meet these requirements. It discusses the use of water quality monitoring data to identify potential compliance issues and develop, in concert with the wholesale system, effective compliance strategies. This chapter is organized into the following sections:

7.1 Data Acquisition
7.2 Communication of Needs to the Wholesale System

## 7.1 Data Acquisition

As part of normal system operations or as required by drinking water regulations, consecutive systems should routinely monitor distribution system water quality. Parameters such as DBP concentrations (TTHM and HAA5), pH, temperature, disinfectant residual (free chlorine, total chlorine, or chloramine),TOC and microbiological parameters (total and fecal coliform, HPC), can be used to characterize distribution system water quality and can be extremely useful in developing a compliance strategy. A historical record of water quality data combined with new data can be particularly useful in isolating and identifying DBP-related issues in the distribution system. The remainder of this section discusses: 1) what parameters a consecutive system might find useful in developing a compliance strategy; 2) when to monitor; and 3) where to monitor. The importance of these routine water quality parameters and their relation to overall DBP formation are further discussed below.

### 7.1.1 Monitoring Parameters

*TTHM and HAA5*

Routine monitoring of TTHM and HAA5 throughout the consecutive system will likely be the most useful tool in determining if compliance with the Stage 2 DBPR will be a concern. Routine TTHM and HAA5 monitoring will also help to determine the requirements necessary to achieve compliance. A comparison of DBP concentrations entering the system to concentrations throughout the distribution system will help to determine if the DBP concentrations entering the consecutive system are too high to achieve compliance with the Stage 2 DBPR, or if the consecutive system is able to employ some strategy to achieve compliance. High DBP locations may need further monitoring and evaluation because they will likely correspond with longer residence time, lower disinfectant residuals, and higher bioactivity. Some of the strategies a consecutive system can implement to control DBP levels in the distribution system include water age management, using alternative disinfectants such as chloramine, managing the chlorine dosages effectively to avoid under- or over-dosing, blending with sources that have low DBP precursor levels, and/or purchasing water from a different wholesaler. These strategies are discussed in more detail in Chapters 4 and 5.

*pH and Temperature*

Water quality parameters such as pH and temperature can also be used to identify seasonal trends and irregularities in distribution system water quality. Seasonal variations in water temperature can affect DBP formation in the distribution system. For instance, higher temperatures increase the reaction rate of DBP formation. Warmer water temperatures will produce higher levels of TTHM and HAA5 unless better removal of precursors is achieved during treatment, alternative disinfection is practiced, or other DBP-minimizing strategies are implemented.

*Disinfectant Residual Data*

Disinfectant residual data should be routinely gathered and monitored throughout the distribution system. A measurable disinfectant residual should be maintained throughout the distribution system, as required by the SWTR, to provide adequate protection against the possible entry of pathogens or untreated water, and to maintain the microbial water quality achieved by primary disinfection.

A low disinfectant residual at consecutive system entry points may indicate increased water age in the wholesale system. However, accumulation of sediments in a pipe, corrosion conditions, biofilm growth, pipe materials, and the pipe lining in either system can also contribute to disinfectant demand. Comparing historical data for a particular site may be helpful in isolating the contributing factors. Strategies to minimize water age are discussed in greater detail in Chapter 4.

Conversely, excessive disinfectant residual concentrations at the consecutive system entry point may also contribute to higher DBP concentrations. In some instances, a high residual entering the system may be necessary for the consecutive system to maintain a residual at the ends of the system, or may be the result of the wholesale system needing to maintain a residual at the end of their own system. Strategies to minimize the disinfectant residual dose, such as the use of enhanced coagulation (which reduces DBP precursor concentrations and disinfectant demand) by the wholesale system at its water treatment plant, moderation of chlorine residual levels through strategic placement of booster chlorination stations, or water age management may help to reduce DBP concentrations in the distribution system.

*Microbial Data*

Microbial data, such as total and fecal coliforms or HPCs, may be useful in identifying potential DBP compliance strategies. Low disinfectant residual and increased microbial activity are most likely to occur at locations with high water age. In such cases, increased disinfectant doses might be considered necessary to maintain the residual and reduce microbiological activity. However, increasing the dose may also lead to higher DBP concentrations. Consequently, a strategy to reduce water age may be more appropriate to prevent increased formation of DBPs. Chapter 4 discusses operational strategies to reduce system water age.

### 7.1.2 Monitoring Frequency

Consecutive systems should collect routine samples for the various parameters discussed above at a regular frequency. To the extent possible, consecutive systems may want to coordinate their monitoring schedule with the wholesale system to provide the most complete analysis of DBP formation. Coordination of sampling schedules allows for more accurate interpretation of data, as it is possible to see the change in water as it moves from one system to the next over the same time period. Coordination of monitoring with the wholesale system is explained in greater detail in Chapter 6.

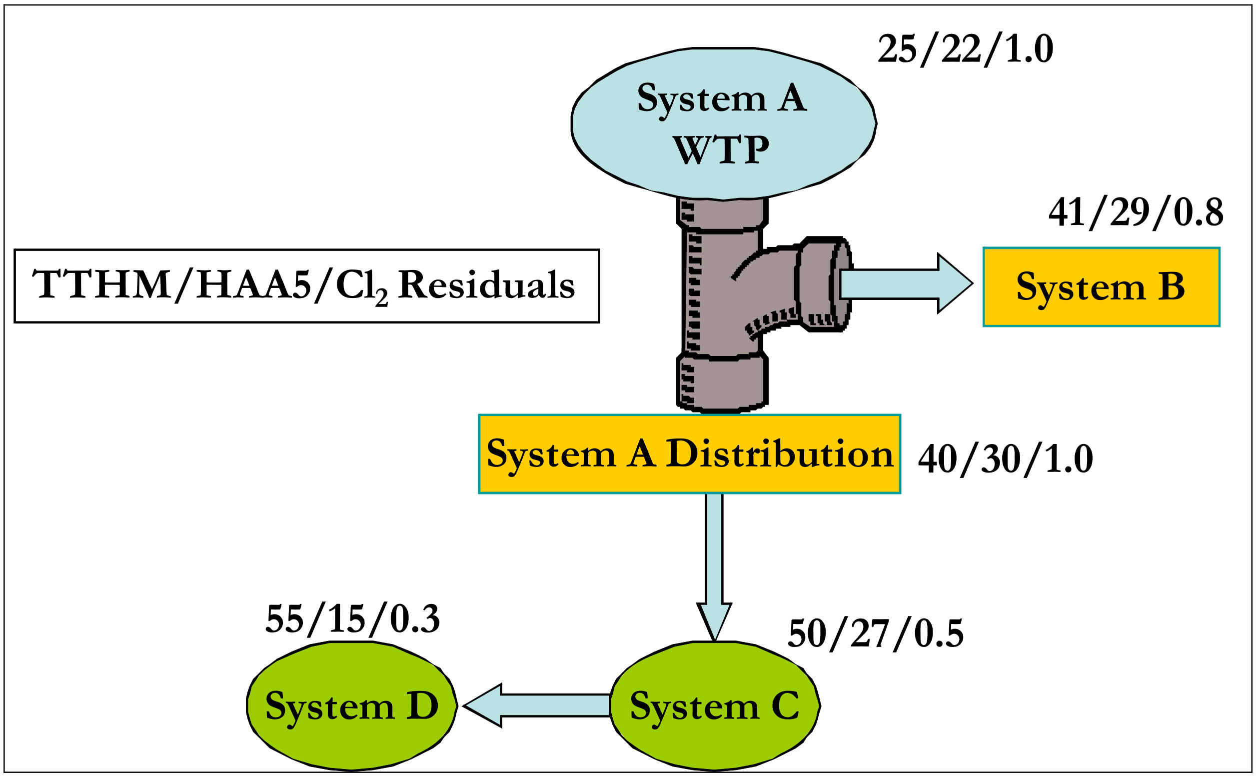
Collecting samples at regular frequencies will help you identify short and long term DBP trends, including seasonal impacts of water quality on distribution system DBP concentrations. Requirements for many parameters, such as disinfectant residual and DBP concentrations, are established by the Stage 2 DBPR. Chapter 3 provides a more thorough discussion of consecutive system monitoring requirements.

### 7.1.3 Monitoring Locations

Samples should be collected throughout the consecutive system distribution system. Sample locations should include locations such as the master meter connection, middle of the distribution system, and near the ends or other areas of the distribution system where the highest water age and DBP levels are expected. Monitoring at many of these locations is already required by the Stage 2 DBPR. If additional sites could be incorporated for monitoring, sampling locations should be spread throughout the distribution system. Samples collected from only one location or region within the distribution system may skew the DBP, disinfectant residual, or microbial data. Understanding how DBP formation varies across the entire system is critical to developing an effective DBP control strategy. Thus, it is important to collect and use data that represent the entire distribution system.

Exhibits 7.1 and 7.2 provide case studies characterizing the differences in wholesale and consecutive system DBP formation. These examples show how TTHM, HAA5 and disinfectant residual concentrations are impacted by differences in disinfection practices from the wholesale system to the consecutive system.

**Exhibit 7.1 DBP Formation from Wholesale to Consecutive System**




Note: WTP = water treatment plant; THMs = trihalomethanes; HAAs = haloacetic acids; Cl2 = chlorine.

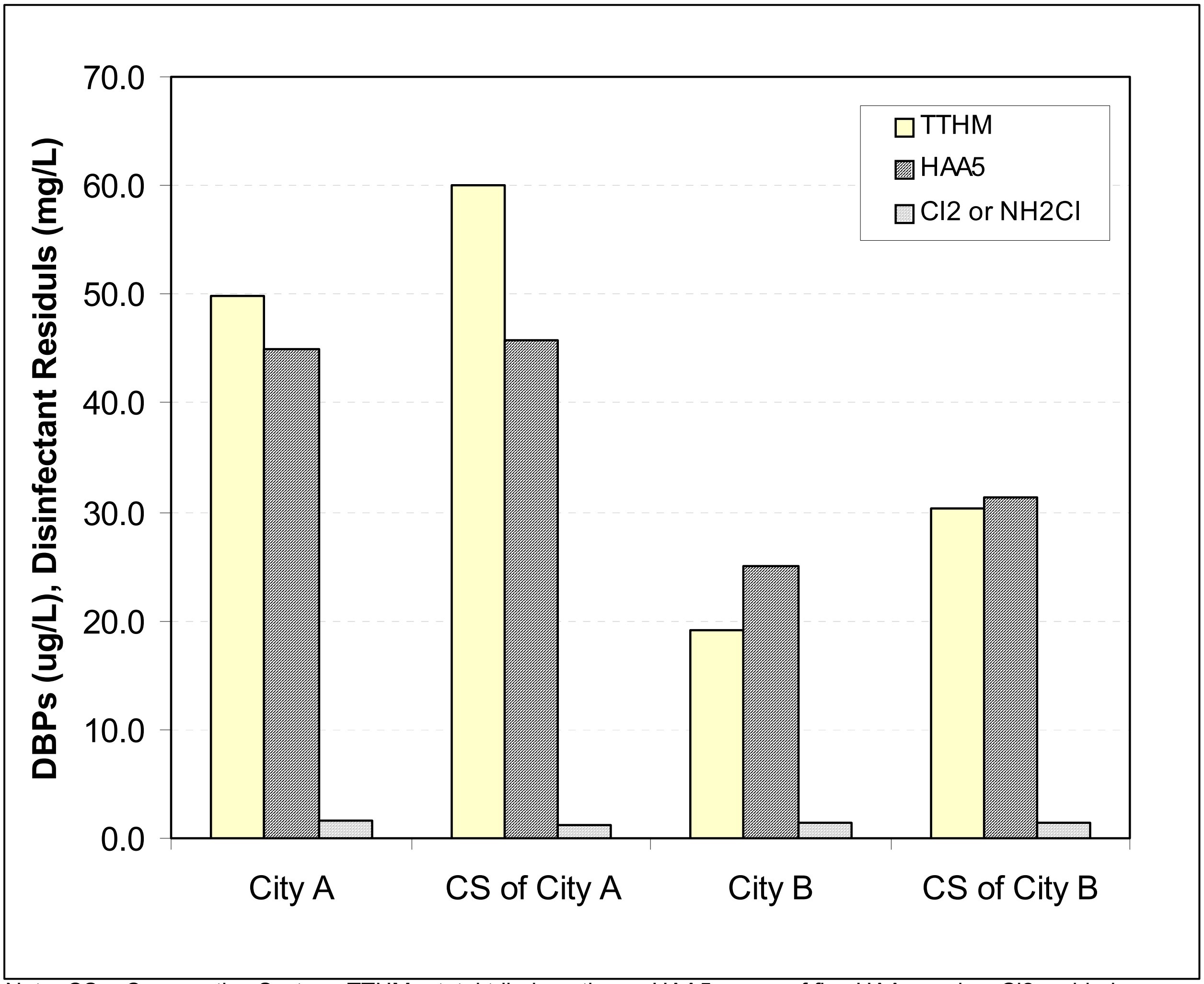
System A is a wholesale system that provides drinking water to more than 100,000 people. Water is treated using an advanced filtration process followed by disinfection using chlorine. The finished water then travels through large transmission lines from the water treatment plant to the distribution system. Finished water is distributed to three consecutive systems. System A supplies water to System B and System C, and System C supplies water to System D.

Exhibit 7.1 illustrates the complex nature of wholesale and consecutive system relationships. This figure shows average TTHM and HAA5 concentrations, and chlorine residuals in the wholesale and consecutive systems. Only wholesale system A and consecutive system B practice booster chlorination to maintain chlorine residuals at acceptable levels. Consecutive systems C and D are smaller systems and do not practice booster chlorination. The chlorine residual in System A's distribution system averages about 1.0 mg/L. An equal or lower chlorine residual is observed in the consecutive systems.

The DBP formation as the water travels from the treatment plant to the distribution systems is also depicted in Exhibit 7.1. Within System A's distribution system, a 40 percent increase in TTHM and a 25 percent increase in HAA5 occurs because it is a large system with booster chlorination systems at various locations. Although consecutive system B receives water directly from the same treatment plant and practices booster chlorination, DBP formation is lower than that of System A because it is a smaller system with lower overall water age. The average TTHM level in consecutive system C is 25 percent higher than System A because of a long transmission main between the two cities. Also, the use of booster chlorination by System

A causes TTHM levels to be fairly high in System C. The increase in TTHM levels from consecutive system C to system D is minimal because these are both small systems with low water age in close proximity to one another. However, the TTHM levels in the consecutive systems are still fairly high because of the impact of System A. A small decrease in HAA5 concentration is noted in the consecutive systems due to biodegradation of some HAA5 species in the distribution system.

### Exhibit 7.2 Variation in DBP Formation with Chlorination and Chloramination




Note: CS = Consecutive System; TTHM = total trihalomethane; HAA5 = sum of five HAA species; Cl2 = chlorine; NH2Cl = chloramines.

Exhibit 7.2 compares DBP formation in City A (chlorinated system) and City B (chloraminated system) which are both large wholesalers. City A uses free chlorine for secondary disinfection. City B uses chloramine for secondary disinfection and also practices booster disinfection. Exhibit 7.2 shows the increase in DBP concentrations from the wholesale to the consecutive system. As would be expected, the overall TTHM and HAA5 concentrations are significantly higher in City A. However, the increases in TTHM and HAA5 concentrations between the wholesale and consecutive systems are more significant in City B. That is, the percentage increases in TTHM and HAA5 concentrations are greater in the chloraminated system than in the chlorinated system. This reflects the fact that while chloramines may result in lower DBP concentrations, significant growth can still occur in the wholesale or consecutive system's distribution system. Monitoring can be a effective tool to identify these relationships in your system. It is worth noting that these results are site/system-specific and may not be typical of results seen in their system.

## 7.2 Communication of Needs to the Wholesale System

If the alternative operational strategies discussed in Chapter 4 are not adequate to control DBPs, consecutive systems should meet with the wholesale system to discuss results and come to a mutually agreed-upon compliance strategy. Chapter 6 discusses communication strategies and agreements between consecutive and wholesale systems in greater detail.

# 8.0 Frequently Asked Questions

***Can I be both a consecutive system and a wholesale system?***

Yes. If you sell water and you purchase water, you are both a wholesale system and a consecutive system.

***I buy all of my water. Do I follow the requirements for subpart H systems or ground water systems?***

If you purchase all of your water and any of it is GWUDI, you must follow the requirements for subpart H systems. If you purchase all of your water and it is all ground water, you should follow the requirements for ground water systems.

***What if my wholesaler only serves groundwater?***

If your system does not have any surface water or GWUDI sources and your wholesaler serves only ground water, you should follow the requirements for ground water systems.

***What if I purchase water but I also have my own sources?***

If your system purchases water, it is considered a consecutive system even if your system has its own sources. Your compliance schedule is based on the population of the largest system in the combined distribution system. However, for purposes of the compliance schedule, the State may determine that the combined distribution system does not include certain consecutive or wholesale systems if water is purchased or sold only on an emergency basis or if only a small percentage and small volume of water is purchased or sold by a system. While your compliance schedule is based on the population of the largest system, your monitoring requirements are based on your own retail population.

***I have my own ground water wells and buy water from a subpart H system. Do I follow the requirements for subpart H systems or ground water systems?***

If you purchase any surface water or GWUDI, you must follow the requirements for subpart H systems.

***What if I buy water from more than one wholesale system?***

If you buy water from more than one wholesale system, you are considered to be part of a combined distribution system that includes all of your wholesalers, all other systems served by your wholesalers, and any systems to which you sell water. If your system is part of a combined distribution system, your compliance schedule is based on the population of the largest system in the combined distribution system. However, for purposes of the compliance schedule, the State may determine that the combined distribution system does not include certain consecutive or wholesale systems if water is purchased or sold only on an emergency basis or if only a small percentage and small volume of water is purchased or sold by a system. While your compliance schedule is based on the population of the largest system, your monitoring requirements are based on your own retail population.

***My system has only undisinfected groundwater sources. I only buy disinfected water in July and August or when my supplies can't meet demand. Do I still have to comply with the Stage 2 DBP Rule?***

Yes, your system is still subject to the Stage 2 DBPR but monitoring is only required during the period when you are buying water. You should contact your State to confirm monitoring requirements.

***Why didn't EPA use § 141.29 for consecutive system monitoring requirements?***

The Stage 2 M-DBP Federal Advisory Committee Agreement in Principle that was signed in September 2000 recommended that the monitoring provisions of the Stage 2 DBPR provide protection for customers in consecutive systems that is equivalent to that provided in wholesale systems. EPA concurred with this recommendation and followed this principle in development of the Stage 2 DBPR.

EPA believes that providing equivalent public health protection in consecutive systems by assigning appropriate compliance monitoring locations throughout the combined distribution system requires case-by-case determinations. These determinations should be based on factors such as the amount and percentage of finished water provided; whether finished water is provided seasonally, intermittently, or full-time; and improved DBP occurrence information. In order to provide systems and States with improved DBP occurrence information, the Stage 2 DBPR requires consecutive systems to address IDSE requirements. § 141.29 by itself would not provide this information. However, since the IDSE will provide improved DBP occurrence information, States may consider modifications to Stage 2 compliance monitoring requirements for consecutive systems on a case-by-case basis as allowed by § 141.29 [or under the special primacy condition at § 142.16(m)(3)] by taking all these factors into consideration. Note that § 141.29 requires case-by-case approval by EPA, but the Stage 2 rule has a special primacy condition that does not require case-by-case approval. In making these case-by-case determinations, the State will be able to use its system-specific knowledge, along with the IDSE results, to develop an appropriate monitoring plan for each system within the combined distribution system.

***What are the minimum monitoring requirements for combined distribution systems if the State modifies monitoring?***

For combined distribution systems for which the State modifies monitoring requirements, the minimum number of Stage 2 DBPR monitoring sites and monitoring frequency will be based on the total population of the combined distribution system. In addition, each consecutive or wholesale system must have at least one compliance monitoring location. Also, each wholesale or consecutive system must conduct its own IDSE. The schedule for your IDSE was based on the population of the largest system in the combined distribution system. The rest of your IDSE requirements were based on your individual system's population. You cannot conduct one IDSE for the entire combined distribution system.

***Why can't my consecutive system forego DBP monitoring and base my compliance status on my wholesaler's compliance status?***

Your consecutive system may *not* base your compliance status on your wholesaler's compliance status because DBPs will continue to form in your consecutive system and may be significantly higher than in your wholesaler's system. Therefore, DBP levels in your consecutive system may exceed the MCL even though your wholesaler is in compliance. Conversely, your DBP levels may be lower than the wholesale system's DBP levels and you should not be in violation if the wholesale system exceeds the MCL. EPA believes that distribution systems and DBP formation are too complex to base compliance determinations on another system's compliance monitoring results.

***Do I have to monitor at the same time as my wholesale system?***

You are not required to monitor at the same time as your wholesaler. However, you may wish to coordinate your monitoring schedule with your wholesaler to better understand DBP formation in your combined distribution system. See Chapter 6 of this guidance manual for details.

***If my wholesaler has a TTHM or HAA5 violation, is my consecutive system in violation?***

Your consecutive system is only in violation if TTHM or HAA5 levels in your distribution system exceed the MCL. However, your State may require additional follow-up monitoring or public notification if your wholesaler has a TTHM or HAA5 violation. If you receive water from the area of your wholesaler's system where the TTHM or HAA5 violation occurred, you may also detect TTHM or HAA5 levels above the MCL in your consecutive system.

***If the lab with whom I have a contract does not collect DBP samples, am I in violation? What if my contract is with my wholesale system?***

Even if you have a contract with your laboratory or your wholesale system, you retain responsibility for the collection of DBP samples. If your laboratory or wholesale system fails to collect your DBP samples, your system will incur a violation.

***Can I use my wholesale system's system-specific study or DBP data instead of monitoring my own system?***

Each wholesale or consecutive system must conduct its own IDSE. The schedule for your IDSE must be based on the population of the largest system in the combined distribution system. The rest of your IDSE requirements must be based on your individual system's population. You cannot conduct one IDSE for the entire combined distribution system.

***What if my wholesaler will not be conducting the monitoring in my consecutive system?***

As a public water system, you are responsible for ensuring that your monitoring is conducted. If your wholesaler will not be conducting monitoring in your consecutive system and you do not have a contract with a laboratory to conduct monitoring in your system, you are responsible for collecting all of your compliance samples in your system, and ensuring that the samples are analyzed in a certified laboratory.

***How do consecutive systems qualify for reduced monitoring?***

There are no differences in how consecutive and non-consecutive systems qualify for reduced monitoring. Consecutive systems qualify for reduced monitoring if the LRAA is less than or equal to 0.040 mg/L for TTHM and less than or equal to 0.030 mg/L for HAA5 at all compliance monitoring locations. In addition, before any treatment, the source water average annual TOC level must be less than or equal to 4.0 mg/L at each treatment plant treating surface water or GWUDI, based on monitoring conducted under the Stage 1 DBPR. Consecutive systems will need to obtain source water TOC monitoring results from all surface water and GWUDI sources used by their wholesaler(s) in addition to their own sources to qualify.

***How is compliance determined for a consecutive system?***

A consecutive system's compliance is based on the LRAA calculated using the sample results collected only in that system's distribution system. However, the State may require the consecutive system to give public notice if the wholesaler has a violation, even if the consecutive system does not incur a violation.

***If my consecutive system is in danger of exceeding the TTHM or HAA5 MCLs, who is responsible for making changes to ensure compliance with the MCLs?***

Even though some agreements between wholesale and consecutive systems may indicate that the wholesale system is responsible for making changes, you are ultimately responsible for providing water that meets the MCLs within your consecutive system. You should consider discussing treatment changes with your wholesaler to reduce DBP levels prior to your entry point. See Chapter 5 for more information. However, if your wholesaler is in compliance with the MCLs, your wholesaler is not required by the Stage 2 DBPR to make any treatment changes to meet the MCLs in your consecutive system. Therefore, you should also consider changes to your distribution system to reduce DBP levels. See Chapter 4 for more information. If you are still unable to meet the MCLs, you should consider an alternate source of water or blending sources. See Chapter 5 for more information.

***What if my wholesaler will not be making treatment changes to meet the Stage 2 DBPR?***

If your system is in danger of exceeding the MCLs for TTHM or HAA5 and your wholesaler will not be making treatment changes to meet the Stage 2 DBPR, you should consider making distribution system changes to reduce DBP levels. Refer to Chapter 4 for more information. If you are still unable to meet the MCLs, you should consider alternate sources of water or blending sources. See Chapter 5 for more information.

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1

# Appendix A
# Example of a Formal Agreement between Consecutive and Wholesale Systems

1

Date: ______________

To the Denver Board of Water Commissioners:

The Board of ____________________________________ (hereafter Distributor) requests to be included in Denver Water's Integrated System under the Colorado Primary Drinking Water Regulations (CPDWR). This Board acknowledges that it is legally and enforceably obligated to comply with Denver Water's Operating Rules and Engineering Standards through its distributor agreement with Denver Water. It further acknowledges that such rules and standards include the standard operating procedures adopted by the reference in Chapter 12 of the Engineering Standards.

Distributor's contact person: ______________________________

Address: ______________________________

______________________________

______________________________

Phone: ______________________________

No. of people served: ______________________________

The responsibilities of the parties are set forth as follows:

Denver Water is responsible for:

( ) all monitoring and MCL requirements related to microbiological contaminants (Article 3, CDPWR)

( ) all monitoring, reporting and MCL requirements related to disinfection byproducts (Art. 5 CPDWR) unless a distributor adds disinfectant in the distribution system

( ) all tap monitoring, reporting, corrosion control and public education requirements of the lead and copper rule (Art. 7, CDPWR)

( ) all collection, reporting and compliance with residual disinfectant requirements (Art. 9, CPDWR)

( ) all public notification requirements (Art.10, CPDWR)

( ) all requirements for annual consumer confidence report (Art. 13, CPDWR)

( ) cleaning of treated water storage facilities (**additional charge required**)

( ) cross-connection control program (Art. 12, CPDWR)

Distributor is responsible for all other requirements for consecutive systems enumerated by Article 1.6 of the CPDWR, specifically including but not limited to:

( ) distribution system operator certification
( ) hydrant inspection program
( ) valve inspection program
( ) lead service line replacement requirements (Art. 7, CPDWR)
( ) operation of treated water storage (**check if distributor has treated water storage**)
( ) water quality customer complaints, communication and initial response
( ) leak repair and main disinfection
( ) distribution system discharges
( ) maintenance of treated water storage (**cleaning can be contracted to Denver Water if checked above**)

( ) Instead of having Denver Water responsible, the Distributor prefers to be responsible for its own cross-connection control program, including all reporting, record-keeping and enforcement of hazardous cross-connection requirements and backflow prevention (Art. 12, CPDWR) (**if checked, cross out and initial the last responsibility under Denver Water**)

Distributor further certifies that it (does/does not) provide further disinfection to the water it receives from Denver Water.

ATTEST:

______________________________
**[NAME OF DISTRIBUTOR]**

By____________________________

By____________________________

______________________________
Title

______________________________
Address

______________________________

ACCEPTED BY DENVER WATER:

Date: ______________

______________________________ Date:__________________________
Manager of Water Quality