EXPLANATION OF THIS DOCUMENT
PLEASE READ

This is a **draft** of the Proposed Revised Total Coliform Rule Assessments and Corrective Actions Guidance Manual (Proposed RTCR A/CA GM). As such, there are a couple of things readers must keep in mind:

- This was developed in response to stakeholders' request. Stakeholders requested that a draft of the guidance manual be available during the public comment period of the Proposed Revised Total Coliform Rule (RTCR) to help them better prepare their comments on the proposed rule.
- This is based on the requirements of a proposed rule. Between now and when the rule is finalized, the requirements may change depending on the comments EPA receives on the proposed rule during the public comment period. Accordingly, EPA will make the necessary changes to the guidance manual to reflect the new requirements of the final rule.
- EPA is not taking any comments on the proposed rule via this draft guidance manual. Any comments on the proposed RTCR must be made through *www.regulations.gov* (search for Docket number EPA-HQ-OW-2008-0878). The Federal Register notice for the proposed rule also includes additional methods for submitting comments on the proposed rule (75 FR 40926, July 14, 2010).

EPA is interested in obtaining stakeholder input in further developing a guidance manual that would be of most use to public water systems and primacy agencies. EPA, therefore, welcomes comments on any aspect of the draft Proposed RTCR A/CA GM (e.g., formatting, organization, content, etc.), but specifically requests comment on the following:

- Should systems be encouraged to submit assessment forms electronically?
- Are there other causes of total coliforms/*E. coli* contamination that should be addressed in this document?
- Are there any other potential corrective actions that have not been noted?
- Are there other examples of assessment in Appendix B that people would like to see discussed instead?
- Should any other AWWA Standards (or other references) be included? Are there ones that need to be deleted?
- Should EPA consider revising the example assessment forms in Appendix A? If so, please provide suggestions for improvements/changes to the forms.

Please submit your comments to *prtcr_acaguide@epa.gov* by November 30, 2010.

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PROPOSED REVISED TOTAL COLIFORM RULE

Assessments and Corrective Actions Guidance Manual

Draft

Office of Water (4607M)
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DISCLAIMER

This manual is intended to provide information to assist public water systems in complying with Level 1 and Level 2 assessment and corrective action requirements under the proposed Revised Total Coliform Rule.

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. While EPA has made every effort to ensure the accuracy of the discussion in this guidance, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. In the event of a conflict between the discussion in this document and any statute or regulation, the statute or regulation would be binding.

Interested parties are free to raise questions and objections to the guidance and the appropriateness of using it in a particular situation.

Although this manual describes suggestions for complying with proposed RTCR requirements, the guidance presented here may not be appropriate for all situations, and alternative approaches may provide satisfactory performance.

Mention of trade names or commercial products does not constitute an EPA endorsement or recommendation for use.

Questions regarding this document should be addressed to:

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DRAFT

CONTENTS

ACRONYMS

AIP	Agreement in Principle
AMWA	Association of Metropolitan Water Agencies
APHA	American Public Health Association
ASDWA	Association of State Drinking Water Administrators
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
CCCBFP	Cross-Connection Control and Backflow Prevention
CFR	Code of Federal Regulations
CWS	Community Water Systems
DBP	Disinfection Byproducts
EC	*E. coli*
EC+	*E. coli*-Positive
EPA	Environmental Protection Agency
FR	Federal Regulations
GW	Ground Water
GWR	Ground Water Rule
GWUDI	Ground Water Under the Direct Influence of Surface Water
HAA5	Haloacetic Acids (5)
HPC	Heterotrophic Plate Count
HRT	Hydraulic Residence Time
IESWTR	Interim Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCWS	Non-community Water System
NPS	Nominal Pipe Size
O&M	Operation and Maintenance
PN	Public Notification
PWS	Public Water System
RTCR	Revised Total Coliform Rule
SCADA	Supervisory Control And Data Acquisition
SOP	Standard Operating Procedures
TC	Total Coliforms
TC+	Total Coliform-Positive
TCR	Total Coliform Rule
TCRDSAC	Total Coliform Rule / Distribution System Advisory Committee
TT	Treatment Technique
TTHM	Total Trihalomethanes
US	United States
USEPA	United States Environmental Protection Agency

1. Introduction and Scope of this Manual

Under the proposed Revised Total Coliform Rule (RTCR) (USEPA 2010b), a public water system (PWS) that is vulnerable to microbial contamination (as indicated by its monitoring results) is required to conduct assessment and corrective action of the system to identify and correct any sanitary defects[1] in the distribution system or treatment processes. This document provides PWSs with guidance on implementing the assessment and corrective action requirements of the proposed RTCR.

1.1 Organization of Document

The document is organized as follows:

- **Chapter 1 – Introduction and Scope of this Manual.** This chapter introduces the guidance manual, summarizes each section of the document, discusses the nature of microbial indicators and their relation to waterborne pathogens, discusses the causes of coliforms and *E. coli* in the distribution system, and provides a description of other relevant guidance documents and that may be useful to the reader.

- **Chapter 2 – Summary of the Proposed Revised Total Coliform Rule.** This chapter summarizes the requirements of the proposed RTCR.

- **Chapter 3 – Assessments.** This chapter presents a detailed overview of the Level 1 and Level 2 assessment requirements under the proposed RTCR and provides guidance to assist PWSs and States[2] in the implementation of these requirements. The chapter also includes discussions on the differences between Level 1 and Level 2 assessments; the elements of assessments; assessment forms; sources of data or information for completing assessment forms and recommendations on how systems should complete assessments given system attributes (e.g., system size, type, disinfection status, etc.); and qualifications of assessors.

- **Chapter 4 – Corrective Action.** This chapter discusses requirements and provides guidance related to the identification and correction of sanitary defects, particularly those in the distribution system. It also provides guidance related to actions that could be taken regardless of the outcome of the assessments.

- **Appendix A – Example Assessment Forms**

- **Appendix B – Examples of Completed Assessments**

[1] A defect that could provide a pathway of entry for microbial contamination into the distribution system or that is indicative of a failure or imminent failure in a barrier that is already in place. Proposed RTCR § 141.851. See Chapter 3.1 of this document for a more detailed discussion of sanitary defects.

[2] In this document, "State" is used to generally refer to the primacy agency, whether it be the State agency, the Tribal government, or EPA. A primacy agency is the entity that has the primary responsibility for administrating and enforcing regulations under the Safe Drinking Water Act (SDWA) in a given jurisdiction. In many cases, the State agency is the primacy agency.

- **Appendix C – Common Sanitary Defects and Corrective Actions**

- **Appendix D – Industry Standards for Operating a Public Water System**

1.2 Nature of Microbial Indicators

The proposed RTCR aims to increase public health protection through the reduction of potential pathways of entry for fecal contamination into the distribution system. Since these potential pathways represent vulnerabilities in the distribution system whereby fecal contamination and/or waterborne pathogens, including bacteria, viruses and parasitic protozoa could possibly enter the system, the reduction of these pathways in general should lead to reduced exposure and associated risk from these contaminants. Fecal contamination and waterborne pathogens can cause a variety of illnesses, including acute gastrointestinal illness (AGI) with diarrhea, abdominal discomfort, nausea, vomiting, and other symptoms. As stated earlier, under the proposed RTCR, a PWS that is vulnerable to fecal contamination (as indicated by its monitoring results for total coliforms and *E. coli*) is required to conduct an assessment of the system to identify and correct any sanitary defects.

Under the proposed RTCR, EPA uses total coliforms as indicators of the integrity of the distribution system, and *E. coli* as an indicator of the presence of fecal contamination.

Total coliforms are a group of closely related bacteria that, with few exceptions, are not harmful to humans. Coliforms are abundant in the feces of warm-blooded animals, but can also be found in aquatic environments, in soil, and on vegetation. Coliform bacteria may be transported to surface water by run-off or to ground water by infiltration. Total coliforms are common in ambient water and may be injured by environmental stresses such as lack of nutrients, and water treatments such as chlorine disinfection, in a manner similar to most bacterial pathogens and many viral enteric pathogens (including fecal pathogens). EPA considers total coliforms to be a useful indicator that a potential pathway exists through which fecal contamination can enter the distribution system. The absence (versus the presence) of total coliforms in the distribution system indicates a reduced likelihood that fecal contamination and/or waterborne pathogens are occurring in the distribution system.

Under the proposed RTCR, each total coliform-positive sample is assayed for *E. coli*. *E. coli* is a more restricted group of coliform bacteria that almost always originate in the human or animal gut (Edberg et al. 2000). Thus, *E. coli* is used as an indicator of fecal contamination.

1.3 Occurrence of Fecal Contamination and Waterborne Pathogens

Fecal contamination is a very general term that includes all of the organisms found in feces, both pathogenic and nonpathogenic. Fecal contamination can occur in drinking water both through use of contaminated source water without sufficient treatment as well as direct intrusion of fecal contaminants into the drinking water distribution system. Lieberman et al. (1994) discuss the general association between fecal contamination and waterborne pathogens. Biofilms in distribution systems may harbor waterborne bacterial pathogens and accumulate enteric viruses and parasitic protozoa (Skraber et al. 2005; Helmi et al. 2008). Waterborne pathogens in biofilms may have entered the distribution system as fecal contamination from humans or animals.

Co-occurrence of indicators and waterborne pathogens is difficult to measure. The analytical methods approved by EPA to assay for *E. coli* are able to detect indicators of fecal contamination but do not specifically identify most of the pathogenic *E. coli* strains. Specialized assays and methods are used to identify waterborne pathogens, including pathogenic *E. coli* such as *E. coli* O157:H7, which is the primary cause of hemolytic uremic syndrome (HUS) in the United States (Rangel et al. 2005). Therefore, an *E. coli*-positive monitoring result is an indicator of fecal contamination (Edberg et al. 2000) but is not necessarily a measure of waterborne pathogen occurrence. However, studies have shown that there is a general association between fecal contamination and waterborne pathogens (Lieberman et al. 1994; Lieberman et al. 2002). Hence, *E. coli* is a meaningful indicator for fecal contamination and the potential presence of associated pathogen occurrence.

1.4 Causes of Coliforms and *E. coli* in the Distribution System

There are numerous factors that can contribute to the presence of coliforms and *E. coli* in the distribution system. Coliform bacteria may be present in the distribution system if three conditions simultaneously occur:

1. A source of coliform bacteria;
2. A pathway into the distribution system or a breach in the system's physical integrity; and
3. A mechanism that allows coliform bacteria to be carried on this pathway into the distribution system or that allows bacteria within biofilms, corrosion tubercles or sediment to enter the water.

Sources of coliform bacteria can include:

- Soil and Water Surrounding Pipes – Coliform bacteria are common in the soil and water surrounding pipes, valves, and other distribution system infrastructure.
- Biofilms and Microbial Growth - Coliforms may attach to or become enmeshed in biofilms on pipe walls in distribution systems, where they are protected from disinfectants. Over time, these coliforms (including their associated pathogens) may detach or slough from biofilms, causing persistent detections and even waterborne disease.
- Corrosion Tubercles - A number of cases have been documented showing the presence of coliform bacteria present within corrosion tubercles.
- Customer Connections - Customer connections and premise plumbing, such as the service line connections to schools, hospitals, public and private housing, and other buildings, can be the source of coliform bacteria when a backflow event has occurred and water and contamination from the building pipes are drawn back into the public water distribution system, due to a change in pressure.
- Materials Used in the Distribution System - In some instances, materials used in the distribution system can result in the presence of total coliforms through contamination of the materials prior to installation. Some materials may also support the growth of coliforms by providing nutrients for microbial growth.

- Sediments - Sediment accumulation can provide a habitat for microbial growth in a distribution system. Furthermore, the sediments can protect the microbes from disinfectants.

Pathways through which total coliform bacteria can enter the distribution system can be:

- Finished Water Storage Facility Deficiencies - Storage tank deficiencies, such as vents without screens, inadequate hatches, access hatches that are not locked, physical openings in storage tank roofs, and lack of a cover, can result in the entry of contaminants. Microorganisms can also be introduced into underground storage facilities from surface water or ground water infiltration or runoff.
- Unprotected Cross Connections - A cross connection is a pathway whereby a connection exists between a non-potable water source and a potable source (e.g., the public water system). Backflow through a cross connection is the mechanism that allows non-potable water to enter the water distribution system.
- Intrusion - Leaks or small holes in the pipe can provide a pathway for contaminants outside of a pipe to enter the distribution system during low and negative pressure events (termed intrusion). Points through which intrusions can occur also include pipe fracture cracks, leaking joints, submerged air-vacuum /air-release valves and deteriorating seals.
- Improper Main Installation, Repair, or Replacement - Main installation, repair, or replacement can result in a loss of pressure and exposure of the pipe interior to contaminated soil and runoff. If sanitary procedures are not followed, contaminants can be introduced into the pipes during the main break repair process.

Mechanisms that allow coliform bacteria to enter the distribution system (assuming a source of contaminants and a pathway are present) or that allow bacteria to proliferate in the distribution system include the following:

- Weather-Related Events - A range of different weather-related events can contribute to the increase of total coliforms, and sometimes fecal indicators in source waters. In other cases, coliforms may enter the distribution system more directly. Types of weather-related events that have been attributed to indicator positive samples include significant rainfall events, droughts, and excessively warm or cold weather.
- Treatment Breakthrough - Failure of the treatment barrier can lead to presence of coliforms in the distribution system.
- Backflow – Backflow that allows the non-potable water to enter the potable system can occur either because of reduced pressure in the distribution system (termed backsiphonage) or the presence of increased pressure in the non-potable system (termed backpressure).
- Hydraulic Conditions - Contaminant intrusion may occur if a very low or negative pressure occurs within the pipe. Low pressure conditions in the distribution system can also allow a flow reversal or backflow of non-potable water to enter the system from a cross connection or other source such as intrusion.
- Operations - Sudden velocity or flow direction changes during operational activities within a distribution system can result in the release of biofilms, scales, or sediments with microbial contamination These velocity and flow changes are sometimes related to fire fighting, valve exercising, and changing from one source to another.

- Maintenance Practices – Maintenance practices such as flushing and line cleaning can affect the distribution system water quality in a negative manner if not conducted properly and improper flushing can result in moving a contaminant further into the distribution system.
- Retention Times - Long retention time in the distribution system can reduce the levels of disinfectant residual and allow for the deposition and accumulation of sediment.
- Presence of Nutrients - Some materials or system operations can introduce nutrients such as carbon, nitrogen, and phosphorus to the distribution system that may support growth of total coliform bacteria.

Additional information on the causes of coliforms and *E. coli* in the distribution system can be found in a series of issue papers and white papers located at *http://www.epa.gov/safewater/disinfection/tcr/regulation_revisions.html*

1.5 Other Relevant Guidance Documents

The reader can refer to the following guidance manuals and documents for more information that may be helpful in complying with the assessment and corrective action requirements of the proposed RTCR.

- **Ground Water Rule Corrective Actions Guidance Manual** (EPA 815-R-08-011; November 2008)
  http://www.epa.gov/safewater/disinfection/gwr/pdfs/guide_gwr_correctiveaction.pdf
  This guide provides guidance in meeting the corrective action requirements of the Ground Water Rule. It provides assistance in determining the information that should be included in a public water system's (PWS's) corrective action plan and assists States and PWSs to select and implement corrective actions in response to significant deficiencies identified during a sanitary survey or in response to fecal contamination of the source water.

- **Sanitary Survey Guidance Manual for Ground Water Systems** (EPA 815-R-08-015; October 2008)
  http://www.epa.gov/safewater/disinfection/gwr/pdfs/guide_gwr_sanitarysurvey.pdf
  This guide provides a brief review of the sanitary survey regulatory provisions for ground water systems, give specific examples of what constitutes a significant deficiency, and provide a checklist of elements that should be evaluated during the course of a sanitary survey inspection.

- **Guidance Manual for Conducting Sanitary Surveys of Public Water Systems; Surface Water and Ground Water Under the Direct Influence (GWUDI)** (EPA-815-R-99-016; April 1999)
  http://www.epa.gov/safewater/mdbp/pdf/sansurv/sansurv.pdf
  This guide provides guidance on how to conduct sanitary surveys of surface water systems and ground water under the direct influence (GWUDI) of surface water systems. It explains the elements of the sanitary survey and presents general guidelines for evaluating the important components of each element.

EPA is also planning to revise the following documents for the final RTCR:

- **Total Coliform Rule: A Quick Reference Guide** (EPA 816-F-01-035, September 2001)
  http://www.epa.gov/safewater/disinfection/tcr/pdfs/qrg_tcr_v11.pdf
  This two page guide provides the highlights of key rule requirements such as routine and repeat sampling requirements, routine monitoring frequencies, compliance and violation information, and public notification and reporting requirements.

- **A Small Systems Guide to the Total Coliform Rule: Monitoring Drinking Water to Protect Public Health** (EPA 816-R-01-017A, June 2001)
  http://www.epa.gov/safewater/disinfection/tcr/pdfs/guide_tcr_smallystemsguide.pdf
  This guide provides information for community water systems that serve fewer than 3,300 people. The guide describes the importance of monitoring drinking water to ensure its quality and protect public health and the monitoring that is required under the Total Coliform Rule. It outlines the steps water systems must take if their samples indicate the presence of coliform bacteria and a worksheet to help keep track of monitoring and follow-up actions.

- **Total Coliform Rule: A Handbook for Small Noncommunity Water Systems serving less than 3,300 persons: One of the Simple Tools for Effective Performance (STEP) Guide Series** (EPA 816-B-06-001, July 2006)
  http://www.epa.gov/safewater/disinfection/tcr/pdfs/stepguide_tcr_smallsys-3300.pdf
  This guide provides information for non-community water systems that serve fewer than 3,300 people. The guide describes the monitoring that is required under the Total Coliform Rule. It outlines the steps water systems must take if their samples indicate the presence of coliform bacteria and a worksheet to help keep track of monitoring and follow-up actions.

- **Total Coliform Rule: A Handbook for Small Non-community Water Systems serving 1,000 Persons or Less**
  A planned guide specifically for systems serving 1,000 persons or fewer given the reduced monitoring requirements that are particular to this group, possibly including one page pullouts and other simple tools for compliance assistance.

2. Summary of the Proposed Revised Total Coliform Rule

The proposed RTCR maintains and strengthens the objectives of the 1989 Total Coliform Rule (TCR) and is consistent with the recommendations in the Agreement in Principle (AIP) signed by the Total Coliform Rule Distribution System Advisory Committee (TCRDSAC)[3]. The rule objectives are: (1) to evaluate the effectiveness of treatment, (2) to determine the integrity of the distribution system, and (3) to signal the possible presence of fecal contamination. The proposed revision better addresses these objectives by requiring systems that may be vulnerable to fecal contamination (as indicated by their monitoring results) to do an assessment, to identify whether any sanitary defects[4] are present, and to correct the defects. Therefore, EPA anticipates greater public health protection under the proposed RTCR compared to the 1989 TCR because of its more preventive approach to identifying and fixing problems that affect or may affect public health. The following table gives an overview of the key provisions of the proposed RTCR. For the full requirements of the proposed RTCR, please refer to 40 CFR[5] Part 141, Subpart Y.

Table 2.1 Summary of Proposed RTCR Requirements

Element	Proposed RTCR requirements
Rule construct §§ 141.52, 141.63, 141.854, 141.859	• The proposed RTCR sets an *E. coli* (EC) maximum contaminant level goal (MCLG) of zero, and an EC maximum contaminant level (MCL) and a coliform treatment technique (TT) based on total coliform (TC) and/or EC monitoring results. • Compliance is based on the presence or absence of TC and EC and is determined each calendar month the PWS serves water to the public (or each calendar month that sampling occurs for systems on reduced monitoring). See sections on "Assessment" and "Violations and Public Notification (PN)" in this table for conditions when the coliform TT and EC MCL are violated. • Assessment and corrective action (if necessary) are required if PWS has a coliform treatment technique trigger. See sections on "Assessment" and "Corrective Action" in this table.
Transition from the 1989 TCR to the RTCR §§ 141.854 to 141.857	• PWSs continue on their existing TCR monitoring schedule when the RTCR is effective. • Ground water (GW) systems serving 1,000 or fewer persons remain on their TCR schedule unless or until the conditions occur as described below or unless otherwise directed by the State. o Non-community water systems (NCWSs) on quarterly/annual monitoring remain on that schedule unless/until they have an event that triggers increased monitoring. See the section on "Increased Monitoring (NCWS)" in this table. o Community water systems (CWSs) on reduced monitoring remain on that schedule unless/until they have an event that triggers them to go to routine monitoring. See the section on "Return to Routine Monitoring (CWS)" in this table. o Monitoring schedules will be evaluated during the "special monitoring evaluation" conducted by the State as part of the periodic sanitary survey.

[3] For more information on the AIP and the TCRDSAC, please go to http://www.epa.gov/safewater/disinfection/tcr/regulation_revisions_tcrdsac.html

[4] See Chapter 3.1 of this document.

[5] Code of Federal Regulations

Element	Proposed RTCR requirements
Routine Monitoring §§ 141.853 to 141.858	• Total coliform samples must be collected at sites which are representative of water quality throughout the distribution system according to a written sample siting plan subject to State review and revision. • Samples must be collected at regular time intervals throughout the month except some small systems may collect them on the same day. • The number of monthly samples is based on population served. Reduced monitoring is available for some small GW systems that meet certain criteria. See the section on "Reduced Monitoring" in this table. • Systems on less than monthly monitoring may be triggered to increase their monitoring if certain conditions occur. See the sections on "Increased Monitoring (NCWS)" and "Return to Routine Monitoring (CWS)" in this table. • Each total coliform-positive routine sample must be tested for the presence of *E. coli* and three repeat samples must be taken. • Monitoring provisions are included for seasonal systems,[6] which require them to monitor monthly, have a sample siting plan, and to demonstrate State-approved start-up procedure. Reduced monitoring may be available for some small seasonal GW systems that meet certain criteria. See the section on "Reduced Monitoring" in this table.
Reduced Monitoring §§ 141.854, 141.855	• NCWSs serving 1,000 or fewer people (GW) – can be eligible to reduce their routine monitoring of 1 sample per quarter (i.e., quarterly) to no less than 1 sample per year (i.e., annual) if they meet the following criteria: o Most recent sanitary survey shows that system is free of sanitary defects, has a protected water source, and meets approved construction standards; o Clean compliance history[7] for a minimum of 12 months; o An annual site visit by the State (or a Level 2 assessment by party approved by State) within the last 12 months and correction of all identified sanitary defects. System must have an annual site visit (or its equivalent) every year thereafter to remain on annual monitoring. • Seasonal systems serving 1,000 or fewer people (GW) can be eligible for reduced monitoring by having an approved sample site plan that designates the time period for monitoring based on demand and vulnerability. o For quarterly monitoring the seasonal system must also have a sanitary survey or site visit or Level 2 assessment within last 12 months; a protected water source; a clean compliance history for a minimum of 12 months, and be free of sanitary defects. o To reduce to 1 sample per year, the seasonal system must meet the criteria specified above for quarterly monitoring and have in place or adopt one or more additional enhancements to barriers to contamination (cross connection control, certified operator, meet disinfection criteria, maintenance of at least 4-log removal or inactivation of viruses, other equivalent enhancements). • CWSs serving 1,000 or fewer people (GW) – may reduce their routine monitoring (1 sample per month) to 1 sample per quarter if it meets the following criteria:

[6] A seasonal system is defined as a non-community water system that is operated in three or fewer calendar quarters per year.

[7] A record of no maximum contaminant level (MCL) violations under 40 CFR 141.63; no monitoring violations under 40 CFR 141.21 or subpart Y; and no coliform treatment technique trigger exceedances or coliform treatment technique violations under subpart Y.

Element	Proposed RTCR requirements
	o State certified operator; o Most recent sanitary survey shows that system is free of sanitary defects (or has an approved plan and schedule to correct them), has a protected water source, and meets approved construction standards; o Clean compliance history for a minimum of 12 months; o Meets at least one of the following criteria: annual site visit by the State or a voluntary Level 2 assessment by a party approved by the State and correction of all identified sanitary defects (or an approved plan schedule to correct them); cross connection control; meet disinfection criteria; maintenance of at least 4-log removal or inactivation of viruses; other equivalent enhancements to water systems as approved by the State. • No other systems are eligible for reduced monitoring.
Increased Monitoring (NCWS) § 141.854	• NCWSs serving 1,000 or fewer people (GW), including seasonal systems, increase from quarterly or annual monitoring to monthly monitoring if one of the following occurs: o Triggered Level 2 assessment or a 2nd Level 1 assessment in 12 months; o EC MCL violation; o Coliform TT violation; or o Two monitoring violations within 12 months if on quarterly monitoring or one monitoring violation if on annual monitoring.
Return to Routine Monitoring (CWS) § 141.855	• CWSs serving 1,000 or fewer people (GW) on quarterly monitoring return to monthly monitoring based on same criteria above for NCWSs serving 1,000 or fewer people (GW).
Return to Reduced Monitoring (After Being Triggered to Increased Monitoring) (NCWS) § 141.854	• NCWSs serving 1,000 or fewer people (GW) must meet the following criteria to return to routine quarterly monitoring after being triggered to increased monitoring: o Within the last 12 months, system must have completed a sanitary survey or a site visit by the State or a voluntary Level 2 assessment by a party approved by the State, must be free of sanitary defects, and must have a protected water source; and o Clean compliance history[7] for a minimum of 12 months. • NCWSs serving 1,000 or fewer people (GW) must meet the following criteria to return to reduced annual monitoring in addition to meeting the criteria for returning to routine quarterly monitoring: o An annual site visit by the State or a voluntary Level 2 assessment and correction of all identified sanitary defects; and o Adoption of one or more additional enhancements to the water system barriers to contamination (cross connection control, certified operator, meet disinfection criteria, maintenance of at least 4-log removal or inactivation of viruses, other equivalent enhancements).
Return to Reduced Monitoring (After Being Triggered to Return to Routine Monitoring) (CWS) § 141.855	• CWSs serving 1,000 or fewer people (GW) must meet the same criteria for qualifying for reduced quarterly monitoring. See section on "Reduced Monitoring" for CWSs serving 1,000 or fewer people (GW) in this table.

Element	Proposed RTCR requirements
Repeat Monitoring § 141.858	• All PWSs must take 3 repeat samples after a TC+ sample at locations specified in the sample siting plan. • For GW PWSs serving 1,000 people or fewer, a single sample can meet both the triggered source water requirements of the GWR and the repeat sample requirements of the proposed RTCR, but only if the State approves the use of the single sample to meet both rule requirements and the use of EC as the fecal indicator. Otherwise, the system must take an additional source sample to comply with the GWR.
Additional Routine Monitoring §§ 141.854, 141.855	• A PWS taking routine samples less than monthly is required to take a minimum of 3 routine samples the following month it serves water to the public after a TC+ sample, unless the State waives the requirement.
Assessment § 141.859	• The PWS must conduct a Level 1 assessment if it exceeds any of the following triggers: o For systems taking ≥ 40 samples per month, the PWS exceeds 5.0% TC+ samples for the month; or o For systems taking < 40 samples per month, the PWS has ≥ 2 TC+ samples for the month; or o The PWS fails to take every required repeat sample after any single routine TC+ sample. • The PWS must ensure that a Level 2 assessment is conducted either by the State or a State -approved party (which could include a qualified PWS employee(s)) if it exceeds any of the following triggers: o The PWS has an *E. coli* MCL violation. o The PWS has a second Level 1 trigger within a rolling 12-month period, or in 2 consecutive years for systems on annual monitoring. • The system must complete the assessment as soon as practical after failure to take a repeat sample or after notification of results (i.e., after it determines that an assessment trigger has been exceeded). • Assessment results and description of corrective action(s) taken will be submitted to the State within 30 days after determination of exceeding the trigger. The State must determine if the assessment is sufficient, whether or not a sanitary defect is found.
Corrective Action § 141.859	• System must correct all sanitary defects found in the assessment. • For corrections not completed by the time the assessment form is submitted, the systems must be in compliance with a State-determined schedule and must notify the State when completed.
Violations and Public Notification (PN) §§ 141.202, 141.203, 141.204, 141.860, 141.861	• EC MCL violation – when any of the following occurs; requires Tier 1 PN. o EC+ repeat sample following a TC+ routine sample o TC+ repeat sample following an EC+ routine sample o Failure to take all required repeat samples following an EC+ routine sample o Failure to test for EC when any repeat sample is TC+ • Coliform TT violation – occurs when a PWS fails to conduct required assessment

Element	Proposed RTCR requirements
	and/or corrective action; requires Tier 2 PN. • Monitoring violation – occurs when PWS fails to take every required routine or additional routine sample in a compliance period, or fails to analyze for EC following a TC+ routine sample; requires Tier 3 PN. • Reporting violation – occurs when a PWS fails to submit a monitoring report or completed assessment form after a system properly conducts monitoring or assessment; requires Tier 3 PN.

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3. Assessments

The purpose of performing assessments is to enhance public health protection by identifying the presence of "sanitary defects" (defects that could provide a pathway of entry for microbial contamination into the distribution system or that are indicative of a failure or imminent failure in a barrier that is already in place). Sampling results can trigger an assessment designed to take a closer look at the system and to identify whether one or more sanitary defects are present. This is a more proactive approach than that of the 1989 TCR and will lead to the identification and correction of problems that may compromise public health.

The RTCR includes two levels of assessments – Level 1 and Level 2 (with the Level 2 assessment being more detailed than a Level 1 assessment) – to recognize the severity of the situation and the varying level of effort required for the assessment. For example, a higher level of effort is needed to diagnose a problem arising from situations of greater potential of public health concern such as repeated Level 1 triggers or an *E. coli* MCL violation. For either Level 1 or Level 2 assessments, the PWS must assure the completion of the assessment as soon as practical after notification of their monitoring results. Having the PWS responsible for having the assessment conducted also serves to strengthen the PWS's capacity to ensure that barriers to contamination are in place and are effective in the future. The PWS will provide the primacy agency a completed Level 1 or Level 2 assessment form within 30 days after determination of exceeding the trigger.

The minimum elements of both Level 1 and Level 2 assessments must include a review and identification of the following:

1. Inadequacies in sample sites, sampling protocol, and sample processing
2. Atypical events that may have affected distributed water quality or indicate that distributed water quality was impaired
3. Changes in distribution system maintenance and operation that may have affected or are affecting distributed water quality including water storage
4. An evaluation of source water quality and treatment changes or conditions that may affect distributed water quality, where appropriate
5. Existing water quality monitoring data.

Level 1 and Level 2 assessments consider the same five minimum elements but the depth of consideration of those elements differ because of the differences in severity among the types of assessment triggers. Similarly, triggering a Level 2 assessment implies that a contamination event may be more complicated and pose a greater risk; the level of skills and qualifications expected for a Level 2 assessor should be sufficient to address the complexity and higher degree of risk. Chapters 3.2 and 3.3 describe the Level 1 and Level 2 assessments in greater detail and clarify the differences between the two. Chapter 3.5 discusses the specific items in the example assessment forms found in Appendix A. States may also tailor specific assessment elements to the size and type of the system and PWSs in turn may tailor its assessment activities based on the specific characteristics of its distribution system.

3.1 Sanitary Defects

As mentioned previously, sanitary defects within the distribution system are defined as defects that could provide a pathway of entry for microbial contamination into the distribution system or that are indicative of a failure or imminent failure in a barrier that is already in place. Proper operation and maintenance of the distribution system is the last protective barrier to microbial contamination of drinking water. If the distribution system is breached, microbial contamination can enter the treated water and be transported to customers, potentially resulting in adverse health outcomes. Therefore it is vital to identify and correct sanitary defects to maintain distribution system integrity and proactively protect public health.

Some examples of sanitary defects are holes in tanks that could allow entry of insects or small animals, breaks in pipes that could allow entry of contaminated water (especially when low pressure events occur), and cracks in well seals or casings.

The goal of assessments is to provide a review of the condition of the distribution system and source water components in order to identify if a sanitary defect exists that could have caused a coliform positive sample. When performing a Level 1 or 2 assessment, the PWS may find one or more sanitary defects. Ideally, the PWS should determine if any of the sanitary defects is the likely cause of the coliform positive samples through an evaluation of data, additional sampling, and investigation of system conditions. Documentation of the PWS findings should be submitted in accordance with the primacy agency requirements. It may or may not be possible to conclusively link the coliform positive samples to a given sanitary defect due to the complexity of distribution system configuration and transport of contaminants throughout the system. Even if the defect cannot be proven to be a likely cause of coliform positive samples, the PWS must correct all sanitary defects that are found to prevent them from providing a pathway to future contamination. The PWS should work with the primacy agency to develop a schedule for correction of sanitary defects if it is not feasible to correct them immediately, which may be the case for corrective actions requiring major construction or capital improvements (e.g., replacement of a well, repairs to a storage facility).

3.2 Level 1 Assessments

The Level 1 assessment consists of a relatively simple examination of the system's source water, treatment, distribution system, and relevant operational practices. The Level 1 assessment is intended as a self-assessment. EPA anticipates that this will be completed by the PWS and reviewed by the primacy agency. If the primacy agency determines that the assessment is insufficient, it will consult with the PWS.

A Level 1 assessment is triggered if sampling results in any one of the following:

1. For systems collecting 40 or more samples per month, the PWS exceeds 5.0% total coliform-positive samples for the month; or
2. For systems collecting fewer than 40 samples per month, the PWS has two or more total coliform-positive samples in the same month; or
3. The PWS fails to take every required repeat sample after any single routine total coliform-positive sample.

For the Level 1 assessment, the PWS should look at conditions that could have occurred prior to the collection of the total coliform-positive sample(s). A Level 1 assessment can often be primarily completed using data on hand at the PWS and conducting limited inspections and does not necessarily include extensive new field investigations. Interviews of appropriate PWS employees can also be a valuable means of obtaining important information. Example conditions that may result in coliform-positive samples include treatment process interruptions, loss of pressure, maintenance and operation activities, wet weather events, and recent operational changes. The PWS should also consider and note the condition of system facilities, such as sample sites, distribution system, storage tanks, and source water. In addition, larger systems may want to target their assessments to specific sections of their distribution system or facilities if they find that the exceedances that triggered the assessment are clustered in one part of the system.

PWSs must document their Level 1 assessment in an assessment form, which they must complete and submit to the primacy agency within 30 days after the PWS has determined that the trigger has been exceeded. For more discussion of the assessment forms, see Chapter 3.4 of this document.

Identifying and correcting sanitary defects early will provide some assurance that the system has addressed the issue that may compromise public health. While the Level 1 assessment is intended to be a relatively simple assessment, it should be conducted thoroughly enough to capture the possibility that there may be multiple sanitary defects. Systems should complete the entire assessment form, even if they believe they understand the apparent cause, to ensure they have a holistic picture of the overall integrity of their system and do not inadvertently overlook a sanitary defect. Ideally, a well-performed Level 1 assessment will prevent most systems from developing conditions that lead to a Level 2 assessment.

3.3 Level 2 Assessments

A Level 2 assessment is a more detailed examination of the system, its monitoring program and results, and its operational practices. The elements of a Level 2 assessment are the same as those of a Level 1 assessment, but each element is investigated in greater detail. A Level 2 assessment will likely include field investigations, additional sampling and additional inspections of facilities beyond those performed in a Level 1 assessment. The level of effort and resources required to implement the Level 2 assessments will be commensurate with a more comprehensive investigation, a higher level review of available information, and may involve the engagement of additional parties and expertise. Table 3.1 presents examples of possible differences in the level of effort between a Level 1 and Level 2 assessment.

Table 3.1 Examples of Possible Differences in Level of Effort between Level 1 and Level 2 Assessments

Level 1 Effort	Level 2 Effort
• Review all monitoring results from appropriate areas of the distribution system for the previous 12 months	• Review all monitoring results from appropriate areas of the distribution system for the previous 12 months • Conduct additional investigatory monitoring
• Review cross connection control records for medium- and high-risk facilities in the area of the positive samples	• Review cross connection control records for medium- and high-risk facilities in the area of the positive samples • Inspect backflow prevention devices in the medium- and high-risk facilities in the area of the positive samples
• Review records of storage tank inspections	• Review records of storage tank inspections • Inspect storage tanks that feed the area of the positive samples
• Review records of inspections of wells and surface water source and weather events	• Review records of inspections of wells and surface water source and weather events • Inspect wells and surface water sources
• Interview sample collectors, distribution system managers, other appropriate employees	• Interview sample collectors, distribution system managers, other appropriate employees • Consult with outside experts, professional engineers • Interview residents and businesses in the area of the positive samples
• Review records of entry point and distribution system disinfectant levels	• Review records of entry point and distribution system disinfectant levels, including historical seasonal changes if any • Conduct additional residual testing at the entry point and appropriate locations in the distribution system
• Review records of distribution system maintenance, especially in the area of the positive samples	• Review records of distribution system maintenance, especially in the area of the positive samples • Inspect on-going maintenance activities
• Notify the State of results and discuss with the State as needed	• Consult with the State about assessment plans and approach, especially if the assessment is triggered by detection of *E. coli*. • Notify the State of results and discuss with the State
• **Conduct on-site inspections as indicated by record reviews and interviews above**	• **Conduct on-site inspections as indicated above**

If the primacy agency determines that the Level 2 assessment is insufficient, it will consult with the PWS. The primacy agency may also direct a PWS to perform an expedited action or additional actions in cases with significant potential for public health impact, such as in the case of an *E. coli* MCL violation. For example, the primacy agency may direct the PWS to

apply temporary disinfection while the assessment is ongoing and before the cause and source of the contamination is determined.

A Level 2 assessment is triggered if sampling results in any one of the following:

1. The PWS has an *E. coli* MCL violation; or
2. The PWs triggers a second Level 1 assessment within a rolling 12-month period, unless the State has determined a likely cause for the situation that resulted in the initial Level 1 treatment technique trigger and establishes that the system has fully corrected the problem; or
3. For systems with approved reduced annual monitoring, a Level 1 treatment technique trigger in two consecutive years.

Level 2 assessments are triggered by events that either (a) pose a potential immediate acute public health threat (i.e., trigger associated with the presence of *E. coli*) or (b) those that do not necessarily pose an immediate acute public health threat (i.e., a second Level 1 trigger) but may still pose a potential serious health impact because of the persistence of the contamination. EPA anticipates that Level 2 assessments following triggers associated with the presence of *E. coli* may be more involved than the Level 2 assessments following triggers in which there is no *E. coli* present, given the differing potential of public health concern.

While the Level 1 assessment is intended as a self-assessment, Level 2 assessments must be conducted by a party approved by the primacy agency due to the higher level of complexity. The party conducting the assessment could be the primacy agency itself, a third party, or the PWS where the system has staff or management with the required certification or qualifications specified by the primacy agency. Chapter 3.7.2 of this document discusses Level 2 assessor qualifications in greater detail.

In addition to the qualifications of the assessor, there are a number of other differences in how Level 2 assessments are conducted versus Level 1 assessments. In a Level 2 assessment, the conditions that could have occurred prior to the total coliform-positive sample(s), as well as the current condition of water system facilities and system operation and maintenance, should be examined in detail, and the system should conduct a physical inspection of suspected facilities. During this examination, it is recommended that the assessor notes any atypical conditions, even if those conditions do not appear to definitively correlate with the total coliform- or *E. coli*-positive samples. The assessor should review past Level 1 assessments and sanitary survey results. The assessor should also consult with others involved in operation or management of the system to gather additional observations and insight as to possible causes for the trigger. This consultation will also help to identify whether there are multiple causes for the trigger and/or sources of contamination. Gathering information on all elements will also be useful in setting a baseline if a PWS triggers another assessment in the future. This baseline information provides a good indication of where additional follow-up may be needed.

As with a Level 1 assessment, PWSs must document their Level 2 assessment in an assessment form, which they must complete and submit to the primacy agency within 30 days after the PWS has determined that the trigger has been exceeded. For more discussion on the assessment forms, see Chapter 3.4 of this document.

The Level 2 assessment should also be conducted thoroughly to capture the possibility that there may be multiple causes for the coliform positive. Level 2 assessments should be conducted as quickly as possible after notification of *E. coli* positive sample results. Assessors should complete the entire assessment form, even if they believe they understand the apparent cause, to ensure they have a holistic picture of the overall integrity of the system and do not inadvertently overlook a potential defect.

3.4 Assessment Forms

As stated previously, PWSs must complete an assessment form (either for a Level 1 or Level 2 assessment) to document their assessment process and submit it to the primacy agency for review. Appendix A of this document contains an example of a Level 1 and a Level 2 assessment form. These forms are intended as conceptual examples to describe practical expectations for the level of resources committed to undertaking either a Level 1 or a Level 2 assessment. Assessments conducted under the proposed RTCR should reflect the substance and effect of the elements of these example assessment checklists. However, primacy agencies may develop their own forms. Systems should contact their primacy agency to check whether to use the example forms presented in this document or a State- or system-specific form.

The assessment forms for both Level 1 and Level 2 assessments in Appendix A are designed to cover the typical elements found within a PWS. For each element, the assessment forms provide suggestions on items to evaluate that are related to the pathways and mechanisms for microbial contamination as outlined in Chapter 1.4. Since an assessment is an examination of a particular PWS, it will therefore have different components for each system depending on the system's source water, configuration, and the number and type of distribution system facilities present. The forms in Appendix A cannot cover all possible situations or distribution system configurations. Assessors should use professional judgment in the application of the forms to their system and provide additional information to support conclusions, if warranted.

The primacy agency makes the final determination on the adequacy and completeness of information provided in the assessment. PWSs should be familiar with the forms and required submittals so that they are prepared for an assessment in advance, should one be required. For example, PWSs may wish to create a standard operating procedure (SOP) for what to do when coliform results trigger a Level 1 or Level 2 assessment. When developing the SOP, systems should verify with their primacy agency whether there is a specific version of the assessment form that needs to be used, and understand which data source(s) they can use to fill out the various sections.

In the completed assessment form, the PWS must identify the results of all elements of the assessment, any sanitary defects detected, corrective actions completed, and a timetable for any corrective actions not already completed. If no sanitary defects are found in an assessment, the assessor may note that no sanitary defects were identified. Upon completion and submission of the assessment form by the PWS, the primacy agency determines if the PWS has identified a likely cause for the Level 1 or Level 2 trigger and establishes whether the system has corrected the problem.

Appendix B provides examples of completed assessment forms. The major elements covered in the forms are discussed in Chapter 3.6 of this document.

3.5 Timeline for Assessments and Corrective Actions

A PWS must complete a Level 1 or Level 2 assessment as soon as practical after the determination that a trigger has been exceeded. The completed assessment form must then be submitted to the primacy agency for review within 30 days after the PWS has determined that a trigger has been exceeded. The 30-day timeframe allows for sufficient time for problem identification and potential remediation of the problem in conjunction with the follow-up assessment, in most cases. If the primacy agency determines that the assessment is insufficient (e.g., the conditions at the well were not fully assessed, or the storage tank was not fully inspected), the primacy agency must consult with the system. If necessary after consultation, the system must submit a revised assessment form to the primacy agency on an agreed-upon schedule not to exceed 30 days from the date of the consultation. For corrections not completed by the time of submission of the assessment form (e.g., in the case where parts need to be ordered and may take longer than 30 days to be delivered and installed), the system must complete the corrective action(s) in compliance with a schedule determined by the primacy agency in consultation with the system. The system must notify the primacy agency when each scheduled corrective action is completed.

3.6 Assessment Elements

The minimum elements of both Level 1 and 2 assessments should include a review and identification of five key elements as outlined in the introduction to Chapter 3. Table 3.2 demonstrates how the questions on the example Level 1 and Level 2 assessment forms in Appendix A correspond to the five minimum elements required by the proposed RTCR.

Table 3.2 Summary of Assessment Form Questions by Element

Element	Questions on the Assessment Forms that Address the Element
Inadequacies in sample sites, sampling protocol, and sample processing	3, 4
Atypical events that may have affected distributed water quality or indicate that distributed water quality was impaired	1, 2
Changes in distribution system maintenance and operation that may have affected or are affecting distributed water quality including water storage	5, 6
An evaluation of source water quality and treatment changes or conditions that may affect distributed water quality, where appropriate	7, 8, 9, 10
Existing water quality monitoring data	1, 2

The following sections discuss the types of activities that a PWS may perform in completing a Level 1 or Level 2 assessment.

3.6.1 Operational Data Review (Questions 1 and 2)

The operational data review includes collection, compilation, and analysis of system data from a variety of sources to get a more complete understanding of system conditions and events that may have occurred prior to triggering an assessment. The data collected should include recent data as well as historical trends to provide a basis for comparison to determine if atypical events have occurred.

The operational data elements should be reviewed by all systems, regardless of size or type. The available data and accessibility of electronic data may vary by system size and type. Large systems may have electronic databases from which to extract pertinent information including:

- Distribution system and treatment plant process data from supervisory control and data acquisition (SCADA) systems for pumping, storage and pressure data
- Water quality measurements from laboratory information management systems (LIMS) or external laboratory reporting systems
- Customer complaint and water usage data from customer service information systems (CSIS)
- Data on operations and repairs in the distribution system from maintenance management information systems (MMIS)
- Recent and historical information from main break databases
- Pipe material and condition information from asset management databases
- Hydrant testing and fire fighting from fire department information
- Activities performed from operations logs.

For smaller systems, much of the data sources listed above may not be electronic and will therefore require additional effort on the system to put together and compile the data as part of the assessment. EPA therefore encourages these systems to maintain records of the above mentioned data elements to help them conduct an assessment should they be triggered to do one.

The operational data review will provide an indication of the elements of the assessment on which to focus efforts. For example, if the SCADA data indicates some low pressure readings in a particular area of the distribution system, follow-up investigations should focus on that area. However, other areas of the distribution system should not be ignored as microbial contamination can be a result of multiple causes.

A Level 1 assessment should include the collection and review of available data. Examples of these data include water quality (e.g., pH, turbidity, etc.) and pressure monitoring data. Tables and graphs summarizing the data and findings could be helpful supplemental items to prepare and submit to the primacy agency, if asked to do so. A Level 2 assessment may include collection of additional data that is not readily available, a deeper examination of correlations between different data sources, hydraulic analysis, and additional sampling, interviews of employees, interviews of customers in the affected areas, inspection of backflow prevention devices in suspect facilities, and more thorough inspection of facilities and sources. For example, in the case where the presence of biofilms is the suspected cause of the positive coliform samples, more sophisticated genotypic characterization techniques can be used to verify if a persistent biofilm microflora is indeed the cause of the contamination. The Level 2 assessment form (Appendix A) includes a series of questions about operational activities and results of data review to provide a basis for the detailed analysis.

Although the PWS is not required to submit the collected data and supplemental analysis with the assessment form, EPA recommends that these items be kept on file for future reference in case the PWS gets triggered to have an assessment again. States may also want to look at these data and analysis during their review of the assessment forms or during a sanitary survey.

Water Quality Data

As part of any assessment, water quality data should be compiled. This data would include parameters collected in the distribution system and at the source or treatment plant. The parameters to be evaluated will vary by system type, treatment process used and other operational practices but may include the items outlined in Table 3.3. If systems do not currently collect water quality data at one of the locations suggested in Table 3.3, they should consider doing so in order to create a baseline for comparison should another assessment be triggered in the future.

Table 3.3 Summary of Typical Water Quality Data to be Evaluated During an Assessment

Water Quality Parameter	Location of Sample Collection
Disinfectant residual concentration	Throughout the distribution system
	At storage tanks throughout the distribution system
	At the entrance to the distribution system at each source
Total coliforms and *E. coli*	All distribution system sampling sites, including those for repeat and additional samples
	Entrance to the distribution system at each source
Heterotrophic plate count	All distribution system sampling sites for total coliforms
Nitrite and nitrate (systems using chloramine)	Distribution system sites with low disinfectant residual
Treatment process performance parameters (e.g. turbidity, pH)	Throughout the treatment process
	Entrance to the distribution system at each source

Once the water quality data have been collected, they should be analyzed to determine if any atypical events have occurred. Depending on the data that are available, there may be several ways to examine the data. One good method is to develop a historical trend for monitoring results and individual parameters at each sampling location. Spreadsheet and graphing software can be helpful in developing and reviewing historic trends. The historical time series can be evaluated visually to determine if there are differences between current results (under assessment) and historical trends. Figure 3.1 provides an example of a historical time series graph of total chlorine measurements from distribution system samples using Microsoft Excel software. The average total chlorine concentration for each month is plotted for multiple years. This type of graph can help to identify if measured values are within normal ranges or

might represent an atypical condition within the distribution system. Similar graphs could be constructed for minimum and maximum residual disinfectant measurements, total coliform positive samples, and related water quality sampling data.

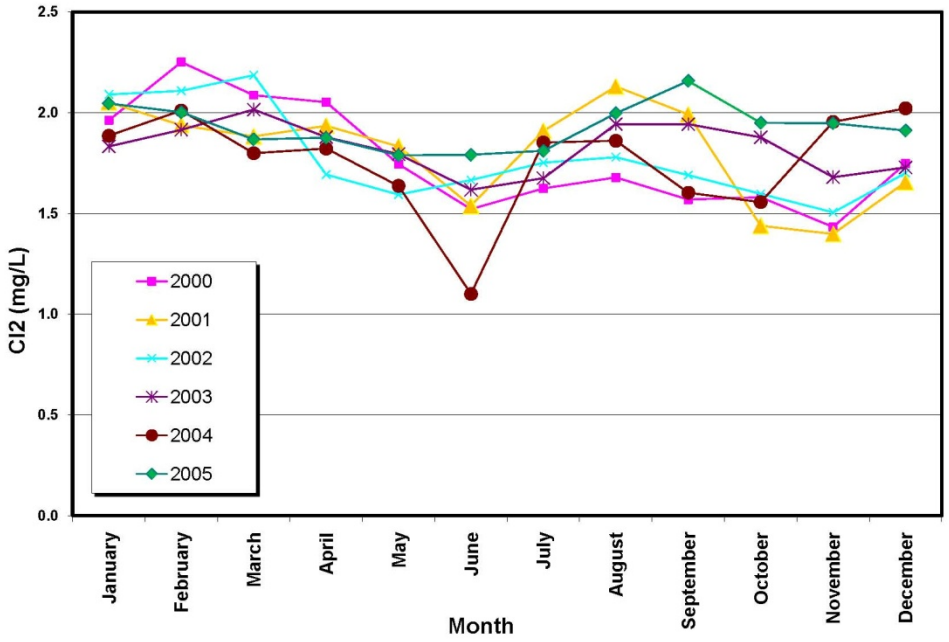


Figure 3.1: Example Time Series Graph for Distribution System Chlorine Results

Additional samples could also be collected to further understand the contamination event. These samples could include follow-up total coliform samples as well as disinfectant residual measurements.

Supplemental data sources beyond water quality measurements could also be considered in the assessment. For example, customer complaints might show an increase in a particular area of the distribution system that could be correlated to distribution system problems. Spatial analysis and mapping of complaints using geographic information system (GIS) software can be helpful in interpreting the data, as illustrated in Figure 3.2. In this example, majority of the complaints regarding the water's color, taste, and odor is occurring in areas where the disinfectant residual is 1.16 mg/L or less.

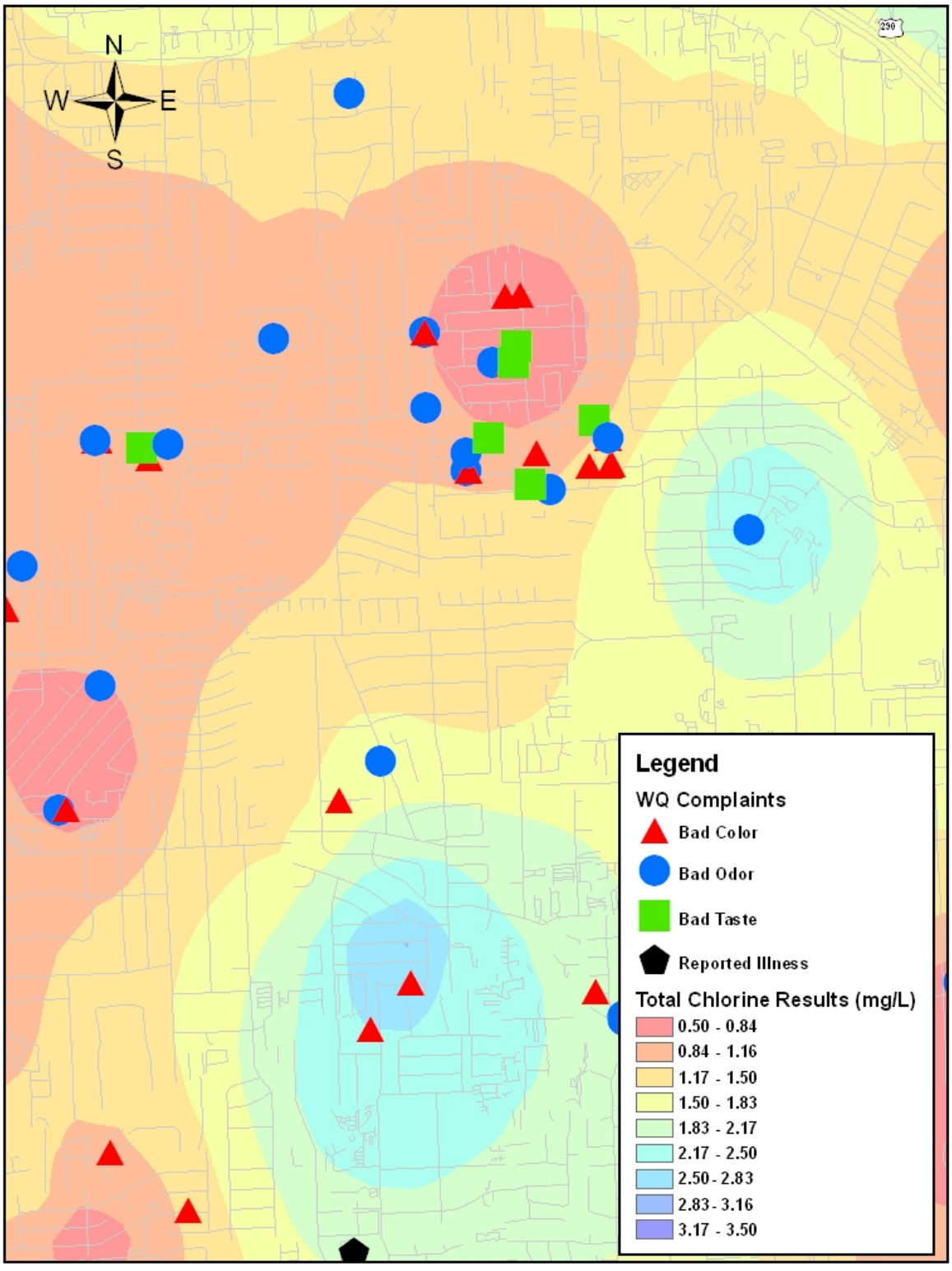


Figure 3.2: Example of Spatial Analysis of Disinfectant Residual and Customer Complaint Data

Public health officials also track reported illnesses, doctor visits, and purchase of over-the-counter medicines. These public health data sources might be helpful in understanding the potential source and extent of contamination. Water systems should work to develop relationships with their local public health officials so that if an assessment needs to be conducted, health information can be more readily accessible.

Operational Activities and Unusual Events

Along with water quality measurements, it is important to understand the extent of activities occurring in the water system that may have resulted in total coliform-positive samples. Compilation of operational activity data may require consultation with different departments within a water utility and with external agencies. The types of activities and events to be noted would include those that might result in distribution system contamination, including:

- Main breaks and associated repairs
- Events resulting in a loss of pressure (e.g., power failures)
- Flushing and hydrant testing
- Construction activity that impacts water mains
- Unusually high (or low) demands that might alter typical flow patterns, including temporary connections for construction and fire fighting
- Break-ins and vandalism at system facilities
- Treatment process upsets
- Weather events
- Source water changes

Once a list of distribution system activities and events has been compiled, this list can be compared to historical records to determine if any activities or events could have led to the distribution system contamination. Further investigation of any suspect operational activities or events should be conducted.

Consideration of flow pathways or use of a hydraulic model can also be useful in determining if a specific activity could be related to the coliform-positive samples at a given location. Figure 3.3 illustrates the output from a hydraulic modeling analysis showing the areas of influence for different pump stations in the system. Locations in this figure are color-coded to show the results of a source tracing analysis, which tracks parcels of water from a selected location. Some locations receive water from more than one source as noted in the figure legend. This type of analysis can be useful in finding the source of contamination, particularly if several positive samples fall within the influence zone of a specific distribution system pump station or tank. In this instance, systems can focus their attention on specific locations at the distribution system in determining the cause of the positive samples. However, as mentioned previously, other areas of the distribution system should not be ignored completely as the contamination can be a result of multiple causes.

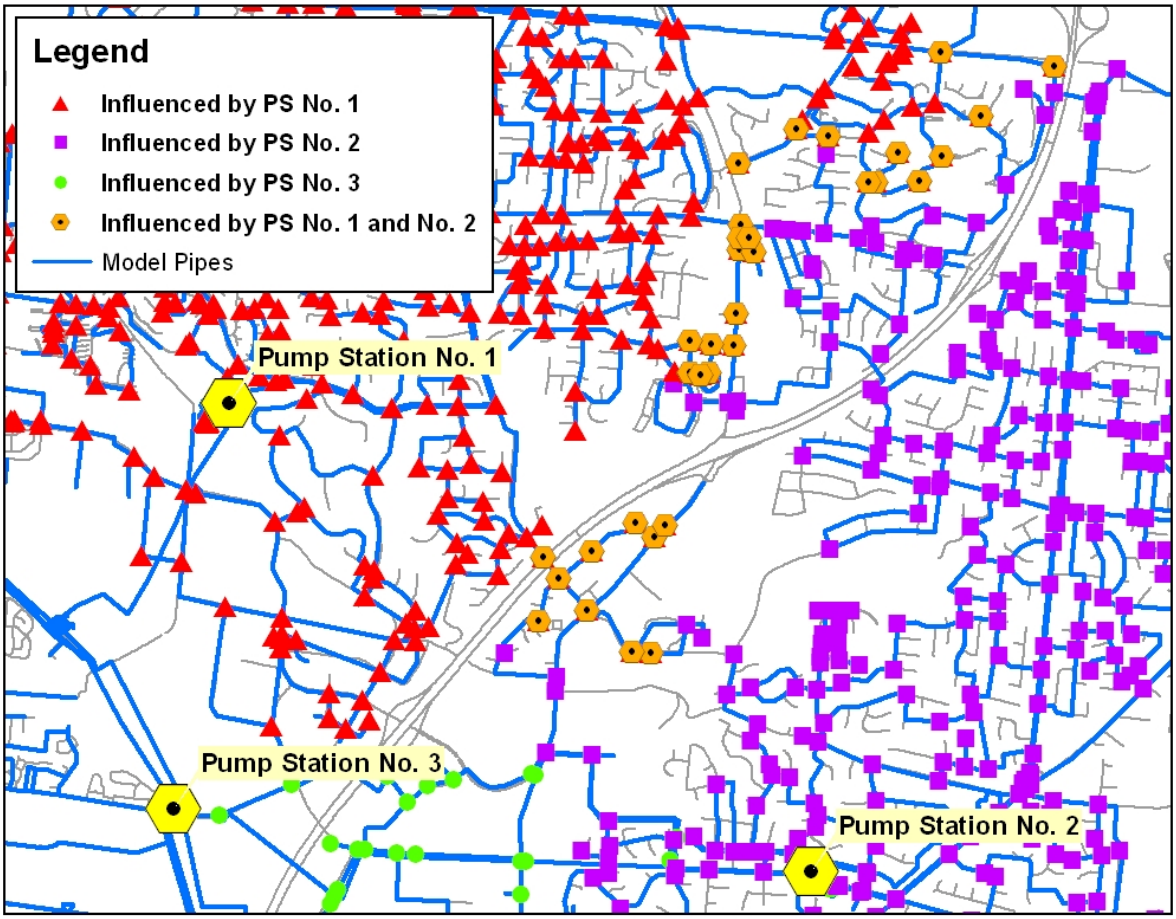


Figure 3.3: Example of hydraulic modeling analysis to determine influence zones for pump stations

3.6.2 Sample Site and Protocol Evaluation (Questions 3 and 4)

This section of the assessment is designed to determine whether water samples could have been contaminated during the sample collection or processing, resulting in total coliform- or *E. coli*-positive samples. In that case, the positive results may not indicate a distribution system problem but rather a sampling problem. Several references are available to provide detailed guidance on sampling (AWWA 2008; APHA et al. 2005; USEPA 2001; USEPA 2006d; USEPA 2006e). EPA intends to review and revise existing guidance and develop additional guidance on monitoring and sampling specific to the RTCR as needed.

The evaluation of the sample site(s) with the positive sample(s) and the sampling protocol would be performed in a similar manner for systems of all sizes and types. Because the sample site(s) is/are a key indicator of whether the problem is system-wide or localized, the assessment would be similar for both a Level 1 and Level 2 assessment, and would include a field visit to inspect the sample location(s) or a detailed discussion with the sample collector to determine the conditions at the sample site(s).

Some of the common items to evaluate at the sample site(s) include:

- Cleanliness and suitability of the sample tap and sink
- Potential for hot water to enter the sample through the tap
- Conditions that may have changed at the sample site since the last sample collection

In addition to sample tap contamination, it is possible that elements of the sampling protocol that were not followed closely could result in contamination of the sample. Elements of the sampling protocol may include:

- Removal of the tap aerator
- Adequate flushing of the tap prior to sample collection
- Proper storage and preparation of the sampling container
- Correct storage, preservation, and handling of sample(s) during transport to laboratory
- Compliance with holding time and temperature requirements

Finally, this evaluation should include a discussion with the laboratory, either in-house or external, to determine if all laboratory quality checks were performed with satisfactory results.

3.6.3 Water System Component Evaluations (Questions 5 to 10)

This section of the assessment addresses the different components of a water system (e.g., the distribution system, storage facilities, etc.) to evaluate the potential for contamination at those areas. The extent to which a PWS should evaluate different components depends on the system configuration and type. Smaller systems would be expected to have fewer components and therefore a lesser level of effort in completing the water system component evaluations. Larger systems may focus their evaluation on areas of the system which have been shown to be more greatly affected, particularly if their data review confirms the extent of spread of the contamination.

A Level 1 assessment for water system components could primarily focus on available data that indicates the condition of the component at its last inspection date, observations from recent visits by operations staff, and other related data such as disinfectant residual that might assist in focusing the assessment efforts. This would include any previously noted sanitary defects or significant deficiencies, and records on how these were addressed. An on-site inspection of components could be considered if it has been a year or more since the last inspection or sanitary survey.

A Level 2 assessment would require a detailed investigation of the components, particularly those near a cluster of positive sample locations. This detailed investigation would require site visits and possibly hiring expert assistance for inspections, particularly for storage tanks that might require specialty equipment and confined space entry safety measures. The Level 2 assessment form (Appendix A) provides a list of questions that should be answered as part of a Level 2 assessment. The questions in the form also provide an indication of the level of detail that should be included for each component evaluation.

For both a Level 1 and Level 2 assessment, the collection of additional samples for total coliforms with potential subsequent *E. coli* analysis and supporting water quality parameters is

encouraged. Systems should keep records of any special purpose samples taken in order to create a baseline for comparison should another assessment be triggered in the future.

Distribution System Components Evaluation

From the operational data review, the PWS should have compiled data to indicate what activities had been occurring in the distribution system, including operational changes, maintenance, and atypical events. Under the distribution system evaluation step of the assessment, further detail should be obtained for any event that might be significant and additional data could be collected. The objective of this evaluation is to determine if a particular distribution system component has a sanitary defect that would require correction, or if distribution system events could have contributed to the positive coliform samples.

The initial focus of the distribution system evaluation should be in the area closest to the positive coliform samples. Operator knowledge or the results of a flow path analysis or hydraulic model can be used to determine the area(s) likely to be associated with a given sample site (see Figure 3.3). Once the immediate area has been examined, the evaluation can continue to areas of the distribution system farther from the positive coliform samples.

Distribution system facilities should be evaluated to determine that equipment is operational and in good repair. The evaluation should include elements such as the ones presented in Table 3.4. Depending on system configuration, not all elements would be present in all systems.

Appendix B includes an example of an assessment where distribution system problems were found. The assessment of the distribution system revealed an air release valve submerged in a flooded valve vault. To correct the problem, a permanent sump pump was installed and portions of the system were shock chlorinated.

Table 3.4 Summary of Items to Evaluate by Distribution System Component

Component	Typical Items to Evaluate
Pump stations	Proper operation of pumps and valves
	Recent losses of power
	Recent losses of pressure
	Proper operation of surge control appurtenances
Distribution system pressure	Maintenance of adequate pressure
Air-relief / Air-vacuum valves	Proper operation of valves
	Valve vault free of standing water and debris
Fire hydrants	Proper operation of shut-off valves
	Leaks at connection to lateral piping
Flushing assemblies / Blow-offs	Proper operation of valves
	Leaks at connection to piping
Pipes	Recent main breaks
	Recent leaks
	Recent installation of new mains or construction activity
Distribution system isolation valves	Recent operation resulting in breakage

Storage Facilities

Storage facilities, or tanks, have been linked to microbial contamination events and therefore are an important component to assess when responding to positive coliform samples (Clark et al. 1996). Microbial contamination can enter storage facilities either through system water or external tank breaches. If contamination is introduced through system water (i.e., transported to the storage facility from a different contamination site), microbes can remain viable and possibly multiply within the tank water and sediments. Table 3.5 outlines some typical items to evaluate for storage facilities. If warranted, a PWS should examine historical disinfectant residual data and collect additional samples.

Table 3.5 Summary of Items to Evaluate at Storage Facilities

Storage Tank Element	Typical Items to Evaluate
Access hatches	Signs of vandalism or forced entry
	Ability of hatch to seal tightly when closed
	Rust, holes, or other breaches
Vents	Signs of vandalism or forced entry
	Holes or other breaches in screens
	Rust, holes or other breaches in vent piping and penetration through tank wall
Overflow piping	Rust, holes or other breaches in piping and penetration through tank wall
Control valves	Correct operation of level control valves, altitude valves, and related appurtenances
Tank exterior	Signs of deterioration, rust, or other breaches
	Locations where ladders, railing, cell tower supports and other attachments are made
Tank interior	Integrity of lining material
	Presence and extent of sediment within tank; existence of microbes within sediment
	Presence of dead animals
Disinfectant residual	Level of disinfectant in tank, ideally at different tank levels

Treatment Processes

For a PWS operating a treatment plant, including those where a chlorinator at a well is the treatmentan assessment of the proper operation of the treatment process is important to determine if a plant upset could be the source of the microbial contamination resulting in positive coliform samples. For most treatment facilities, regulatory data collected for compliance with related treatment requirements (e.g., Surface Water Treatment Rule, Ground Water Rule) should be available. A review of this data may indicate a potential treatment plant problem that could have allowed microbial contaminants to enter the distribution system. When reviewing the treatment data, particular attention should be paid to disinfection processes and turbidity removal, as these processes are responsible for the majority of microbial inactivation (Letterman et al. 1999). For disinfection processes, the disinfectant feed systems and resulting disinfectant concentration should be evaluated to ensure that proper dosing has taken place and desired residuals are maintained. For turbidity removal, coagulation/sedimentation and filtration processes should be evaluated to ensure that microbial contaminants could not have entered the distribution system along with a spike in turbidity. Power outages and other events that disrupt normal operations should also be considered.

Appendix B includes an example of an assessment where a treatment system was determined to be the cause of positive coliform samples. In this case, pressure was lost during regular maintenance of a treatment system and the system may not have been properly disinfected prior to resuming service.

Table 3.6 Summary of Treatment Elements to Evaluate

Treatment Element	Typical Items to Evaluate
Equipment (pumps, mixing units, settling units, pipes, valves, chemical feed units, filters)	Equipment operational and maintained in accordance with the treatment plant Operation and Maintenance procedures
	Recent installations or repairs
Treatment Process	New sources
	Recent changes in the treatment process
	Interruptions in treatment – lapses in chemical feed or proper mixing
	Turbidity measurements at all appropriate locations in the treatment process (source, settled water, pre- and post-filtration, finished water, etc.)
	Disinfectant residual measurements and C x T calculations
	Flow rates at each plant process

Wells

For systems served by wells, the assessment should verify the integrity of the well and proper operation of the well system to ensure that contamination could not have entered the distribution system from the wells. Particular attention should be paid to potential pathways that would allow the entrance of surface water, soil, animals, or other foreign matter into the well. The well should also be constructed to prevent the accumulation of surface water around the well head and prevent inundation during periods of flooding or increased runoff. Table 3.6 outlines some typical items to evaluate for wells. Some elements may not be present depending on the design/configuration of the well and the type of pump in the well.

Table 3.7 Summary of Items to Evaluate at Wells

Well Element	Typical Items to Evaluate
Well house / enclosure	Signs of vandalism or forced entry
Well cap / Well seal	Tightness of well cap or seal, presence of gaps or openings
Well vent	Vent properly screened, self-draining, and has sufficient height above ground
Well casing	Holes, breaks, corrosion or deformation in casing and welds
Annular grout seal	Missing, sunken, bridged, or channeled grout surrounding the well casing
Pump and pump assembly	Attached to casing with no unprotected openings and has watertight seal
Pitless adaptor	Integrity of pitless adaptor connection
Inundation	Signs of inundation by floodwater or runoff; depressions around wellhead

Appendix B provides an example of an assessment where well contamination was the likely cause of positive coliform samples. The well was found to have unsanitary conditions, possibly due to recent flooding, and a corroded casing.

Springs

For systems served by springs, the assessment should verify the sanitary condition and proper operation of the spring and associated piping. The PWS should evaluate the condition of the spring development, impacts from surface water runoff and weather conditions, and the physical condition of the spring box. Impacts from vandalism or forced entry should also be evaluated to determine if holes or other breaches could have occurred that would allow for the introduction of microbial contaminants. Signs of inundation should be checked, including deposits of soil or soil erosion.

Appendix B includes an example of an assessment where a spring source was contaminated through a broken pipe. The pipe was replaced to correct the defect.

Surface Water Sources

Surface water sources can be impacted by climatic events which can influence the influent water quality to a given treatment process. Atypical events may impede the ability of the treatment process to perform as desired and may allow for the introduction of microbial contaminants into the distribution system. Heavy rainfall and rapid snowmelt can carry large soil loads into surface water sources, thereby increasing turbidity and baseline microbial contaminant concentrations. Similarly, flooding can alter the raw water quality and require treatment changes to achieve good finished water quality.

For systems with several surface water sources, a change from one source to another could trigger a treatment upset that might result in microbial contamination entering the distribution system.

3.7 Qualifications of Assessors

3.7.1 Level 1 Assessors

A Level 1 assessment is a PWS self-assessment that should be conducted or managed by a responsible party of the PWS. This should be someone familiar enough with the system to answer the questions in the Level 1 assessment form or to gather correct information from others who work for the system.

3.7.2 Level 2 Assessors

Ideally, a well-performed Level 1 assessment will prevent most systems developing conditions that will trigger them to conduct a Level 2 assessment. However when it does occur, a Level 2 assessment is triggered by a more significant event; therefore a more comprehensive assessment is needed. The level of effort and resources committed to undertaking a Level 2 assessment, relative to a Level 1 assessment, will be commensurate with the more comprehensive investigation and review of available information, and the engagement of additional parties and expertise. A Level 2 assessment will likely include field investigations, sampling and additional inspections of facilities beyond those performed in a Level 1 assessment.

Level 2 assessments must be conducted by a party approved by the State. Examples of such parties may include:

- State or primacy agency personnel
- An operator certified by the State to operate a system of similar size, type, and complexity
- Circuit rider
- A utility supervisor or manager supported by various utility experts
- A consultant/consulting engineer

For small non-community water systems:

- Licensed plumber
- Licensed well driller

The State will determine its criteria and process for approval of Level 2 assessors and will determine which of the above parties are appropriate to conduct the assessment given the complexity of the system and the policies of the State. If the PWS or a third party conducts the Level 2 assessment, the PWS or third party must follow the State requirements for conducting the Level 2 assessment. Systems should be aware of who may be appropriate assessors for their PWS so that if the Level 2 assessment is ever triggered, the PWS does not lose time in identifying who will conduct this assessment. When a Level 2 assessment is triggered, the PWS should resolve uncertainties about the assessor by consulting with the State as soon as possible.

Qualities of a Level 2 assessor may include:

- An understanding of the objectives and structure of the RTCR
- An understanding of the nature of the coliform group and *E. coli*, including its sources, control, and public health significance

- A familiarity with bacteriological sampling practices
- A working knowledge in how to interpret distribution system water quality data
- A working knowledge in how to interpret distribution system water operational data
- A working knowledge in how to interpret source of supply data
- An understanding of disinfection practices, and the potential implications of changes in disinfection practices
- Familiarity with the system

In general, the assessor needs "working knowledge" to oversee all elements covered by the Level 2 assessment. The depth of the understanding and knowledge required will depend on the complexity of the system being assessed. For example, a small system with only a well, storage tank and limited distribution system will require a different level of expertise than a large metropolitan water system. While both have operational data, in one case the assessor may be interpreting information manually recorded from a pressure gauge while in the other case the assessor may need a working familiarity with SCADA.

It is important to recognize that in some cases, one individual may not have all the expertise and a team approach may be needed. It is also worth noting that utilities may gain value from having someone outside their system provide a "fresh set of eyes". The State may wish to consider allowing certified operators with the appropriate qualifications to conduct Level 2 assessments at other systems.

3.8 Assessments and Sanitary Surveys

The performance of sanitary surveys and assessments (when triggered to do so) are important tools in protecting the quality of drinking water. Sanitary survey requirements for surface and ground water systems have been established for all system sizes and types under the Interim Enhanced Surface Water Treatment Rule (IESWTR) (USEPA 1998a) (40 CFR 142.16(b)(3)), and the Ground Water Rule (GWR) (USEPA 2006b) (40 CFR 142.16(o)(2)(i)). Hence, the proposed RTCR does not include new performance requirements for sanitary surveys (e.g., how and when to conduct sanitary surveys). However, the results of a sanitary survey can impact a system's monitoring frequency under the proposed RTCR (see additional discussion in "*What are the overlaps between sanitary surveys and a Level 1 or Level 2 assessment?"* in this section).

This section is not intended to represent guidance on the performance or requirements of conducting sanitary surveys. Other resources are available for that purpose. Sanitary survey resources, such as a prep course, learner's guide, and inspector's field guide can be found on line at *http://www.epa.gov/safewater/dwa/sanitarysurvey/*. This section discusses basic differences between sanitary surveys and Level 1 and Level 2 assessments. Specifically, this section addresses what a sanitary survey is, how often it is performed, the objective of a sanitary survey, and who does them relative to Level 1 and Level 2 assessments.

What is a sanitary survey?

A sanitary survey is a comprehensive on-site evaluation of all water system components and operations and maintenance procedures. Specifically, a sanitary survey is defined in 40 CFR 141.2 as an "onsite review of the water source (identifying sources of contamination using

results of source water assessments where available), facilities, equipment, operation, maintenance, and monitoring compliance of a public water system to evaluate the adequacy of the system, its sources and operations and the distribution of safe drinking water." The requirements specify eight elements that must be included in a sanitary survey: (1) source; (2) treatment; (3) distribution system; (4) finished water storage; (5) pumps, pump facilities, and controls; (6) monitoring and reporting and data verification; (7) system management and operation; and (8) operator compliance with State requirements. The performance of comprehensive and periodic sanitary surveys is important in the identification and correction of significant deficiencies to ensure the long-term safety of drinking water supplies. Sanitary surveys are important tools for identifying potential vulnerabilities to fecal contamination.

What are the differences between a sanitary survey and a Level 1 or Level 2 assessment?

Scope

A sanitary survey is much broader in scope than either a Level 1 or Level 2 assessment. Although a sanitary survey includes elements that are similar as in an assessment (e.g., evaluation of the source water, the distribution system, storage facilities, etc.), it covers other elements such as system management and operation, and operator compliance with State requirements that are beyond what an assessment requires. The Level 1 and Level 2 assessments are specific to only those elements related to sanitary defects that provide pathways of entry for microbial contamination or those that are indicative of a failure or imminent failure in a barrier that is already in place. More information regarding the specific elements of Level 1 and Level 2 assessments can be found in Chapter 3.5 of this document.

Frequency

Sanitary surveys are performed periodically and routinely on a schedule. The State must complete sanitary surveys for all surface water systems (including ground water under the direct influence of surface water) no less frequently than every three years for community water systems and no less frequently than every five years for non-community systems. Ground water community water systems must have sanitary surveys no less than every three years, with the possibility of having the frequency reduced to no less than every five years if the system has an outstanding performance. Non-community ground water systems (both non-transient and transient non-community) are required to have sanitary surveys no less than every five years. Level 1 and Level 2 assessments on the other hand are performed in response to treatment techniques triggers so they are not on a routine schedule. Specific triggers for Level 1 and Level 2 assessments are found in Chapters 3.2 and 3.3 of this document, respectively.

Who conducts them?

Sanitary surveys must be conducted by the State or an agent approved by the State or primacy agency. A Level 1 assessment as indicated in Chapter 3.2 is a self-assessment completed by the qualified PWS staff and reviewed by the State or primacy agency. A Level 2 assessment is conducted by a party approved by the State. It could be conducted by the State or primacy agency, an approved third party, or qualified PWS staff or management who meet the certifications or qualifications specified by the State or primacy agency. Chapter 3.7 of this document discusses specific qualifications of assessors.

What are the overlaps between sanitary surveys and a Level 1 or Level 2 assessment?

Sanitary survey outcomes can impact monitoring requirements under the proposed RTCR. For example, the proposed RTCR allows all systems to transition to the new rule at their current TCR monitoring frequency, including systems on reduced monitoring under the current TCR, provided they meet certain criteria. For systems serving 1,000 or fewer people, monitoring frequency will be evaluated during each sanitary survey conducted after the compliance effective date of the RTCR. The proposed RTCR does not change existing sanitary survey requirements under the IESWTR and the GWR except to add the special monitoring evaluation that States must conduct at systems serving 1,000 or fewer people. The purpose of these special monitoring evaluations is to ensure that the distribution system is evaluated in sufficient detail. These special monitoring evaluations are not anticipated to significantly increase the burden of conducting sanitary surveys because the systems (serving 1,000 or fewer people) are relatively simple, and the evaluation is performed during the routinely scheduled sanitary survey.

For years in which the State performs a sanitary survey of a NCWS (at least every five years for NCWSs), a sanitary survey performed during the same year can also be used to satisfy the annual site visit requirement for systems wanting to qualify for annual monitoring. Also, in some instances, the performance of an assessment (especially a Level 2 assessment) may overlap with a scheduled sanitary survey. To the extent that the requirements to perform an assessment may be satisfied as part of the sanitary survey, PWSs and States may realize a cost savings compared to performing a separate assessment. It must be kept in mind though, that the assessment must be conducted within the required timeframe and not be delayed to when the sanitary survey is scheduled to be performed. Also, the person doing the assessment would have to be qualified to conduct a sanitary survey and the investigation would have to meet the minimum criteria of both the assessment as well as the sanitary survey.

Sanitary defects that are identified during an assessment may or may not be considered to be a significant deficiency according to the guidelines set by the primacy agency. The PWS should coordinate with their primacy agency regarding whether the Level 2 assessment can be considered part of a required sanitary survey.

4. Corrective Actions

This chapter discusses the corrective action requirements of the proposed RTCR and various examples of corrective actions that can help mitigate or eliminate sources of coliform contamination that may occur during operation and maintenance of a treatment process or a water system. Table 4.2 provides a summary of those corrective actions, and the purpose or type of water quality problem addressed by each action.

As mentioned in Chapter 2, the three main objectives of the proposed RTCR are: (1) to evaluate the effectiveness of treatment, (2) to determine the integrity of the distribution system, and (3) to signal the possible presence of fecal contamination. While a number of other regulations also focus on treatment (such as the suite of Surface Water Treatment Rules or the Ground Water Rule), the proposed RTCR builds on the barriers established at the source and treatment plants and seeks to maintain a sufficient barrier in the distribution system. The corrective actions described in this chapter represent key actions for maintaining or restoring the integrity of the distribution system barrier. This multiple barrier approach is essential to protecting public health and systems may find that the corrective actions listed in this chapter may improve their compliance for a number of regulations, not just the proposed RTCR. The interrelated nature of regulations can also be a challenge as adjustments to improve compliance for one rule may inadvertently affect a system's ability to comply with another rule. Issues such as these can be managed with careful consideration and are addressed in Chapter 4.4 of this document.

4.1 Common Causes

An overview of general causes of total coliforms and *E. coli* in the distribution system was presented in Chapter 1.4. Discussions and informal surveys with States and PWSs[8] have identified the following as some of the common causes of total coliforms and *E. coli* detections in the distribution system, a number of which are interrelated:

- Failure to disinfect (or improper disinfection) after maintenance work on the distribution system
- Main breaks, especially in certain vulnerable locations such as under a stream or high groundwater level
- Holes in storage tank, inadequate screening, etc. which could allow animals and/or fecal matter to enter the tank
- Loss of system pressure (sometimes associated with main breaks or loss of power)
- Lack of regular flushing programs
- Biofilm build-up in the distribution system, including biofilms at multiple locations or that move throughout system, or those associated with seasonal changes and/or loss of disinfectant residual

[8] Informal surveys of their constituents were conducted from February to March 2010 by the American Water Works Association (AWWA), the Association of Metropolitan Water Agencies (AMWA), and the Association of State Drinking Water Agencies (ASDWA) to determine the common causes of coliform-positive results in the distribution system and the types of corrective actions taken in response to those positive results.

- Cross connections, especially at certain high-risk locations (e.g., hospitals, chemical plants, chemical holding/storage facilities, funeral homes, etc.)
- Inadequate disinfectant residuals
- Contaminated sampling taps
- Sampling protocol errors.

The specific cause(s) of total coliforms and *E. coli* in the distribution system will differ from system to system. The Level 1 and Level 2 assessments discussed in Chapter 3 are designed to help identify the specific causes so they can be appropriately addressed.

4.2 Common Corrective Actions

The type of corrective action performed will depend on the identified cause. Some actions can be performed in response to multiple types of causes, and multiple actions may be needed in response to a single identified cause. Table 4.1 describes some common general actions that would be taken in response to the common causes listed in Chapter 4.1. Each of the corrective actions listed in Table 4.1 are described in more detail in the following sections, along with examples that can help mitigate or eliminate the sources of coliform contamination. Table 4.2 summarizes these actions along with the general purpose for taking such actions.

Corrective actions should be completed in accordance with State guidance and industry best practices. States often have guidance for operation and maintenance of the water system, and for emergency response planning and implementation of cross connection control programs. Systems should be aware of State guidelines for investigation, operation and maintenance, and corrective action, and consult with the State as necessary to complete corrective actions that the State will consider to be sufficient. An example of State guidance is the *Recommended Standards for Water Works* (also known as the 10 States Standards) (Great Lakes et al. 2007).

Appendix C of this document presents additional information on the common causes of coliform detection in the distribution system, possible corrective actions which systems can take to correct the problem, and additional sources of information for correcting the problem.

Drinking water system components that are used to implement correction actions to distribution system problems should be in compliance with NSF/ANSI Standard 61. NSF/ANSI Standard 61 addresses drinking water system components that are in contact with finished drinking water and whether contaminants leach or migrate from the product/material into the drinking water at levels that are above acceptable levels in finished waters.

In addition, Appendix D contains a listing of AWWA Standards that are typically minimum best practices and help to ensure that a product (e.g., pipes, fittings, meters, etc.) or a process (e.g., main flushing, main installation, etc.) described in a standard will provide satisfactory service. These standards can be valuable resources in implementing corrective actions.

Table 4.1: Common Causes and Associated Common Corrective Actions

Common Cause	Common Corrective Action(s)
Failure to disinfect (or improper disinfection) after maintenance work in the distribution system	Disinfection
Main breaks	Disinfection Replacement/Repair of Distribution System Components
Holes in storage tank, inadequate screening, etc.	Replacement/Repair of Distribution System Components Maintenance of Storage Facility Addition of Security Measures Development and Implementation of an Operations Plan
Loss of system pressure	Maintenance of Adequate Pressure Addition or Upgrade of On-line Monitoring and Control
Biofilm accumulation in the distribution system	Flushing Maintenance of Adequate Pressure
Cross connections	Maintenance of Adequate Pressure Implementation or Upgrade of a Cross Connection Control and Backflow Prevention Program
Inadequate disinfectant residuals	Disinfection Flushing Maintenance of Appropriate Hydraulic Residence Time Addition or Upgrade of On-line Monitoring and Control
Contaminated sampling taps	Replacement/Repair of Distribution System Components Sampler Training
Sampling protocol errors	Sampler Training Development and Implementation of an Operations Plan

Table 4.2 Summary of Corrective Actions

Action	Purpose
Disinfection (Chapter 4.2.1)	Improve or maintain disinfectant residual in the distribution system.
Flushing (Chapter 4.2.2)	Keep system clean and free of sediment. Reduce disinfectant demand of pipe surfaces. Remove stagnant, untreated, or contaminated water. Address water quality deterioration at dead-ends.
Replacement / Repair of Distribution System Components (Chapter 4.2.3) Valves Water Mains Fittings Hydrants Meters Dedicated Sample Taps	Reduce potential sources / pathways of contamination from improper installation or material degradation.
Maintenance of Adequate Pressure (Chapter 4.2.4) Booster Pumping Stations Pump Modifications or Replacement Variable Frequency Drive Elevated Storage Facilities Surge Relief Valves Surge Tanks	Minimize sudden changes in water velocity which impact system pressure. Reduce risk of backflow and intrusion contamination resulting from low pressures. Reduce risk of hydraulic disturbances to pipe surface biofilm.
Maintenance of Appropriate Hydraulic Residence Time (Chapter 4.2.5) Looping Dead-Ends Installing Appropriate Main Sizes Automated Flushing Devices Storage Facility Modifications	Mitigate water quality problems associated with increased water age (e.g., higher DBP formation, reduced disinfectant residual, increased microbial activity, nitrification, and taste-and-odor problems).
Maintenance of Storage Facility (Chapter 4.2.6) Inspecting / Cleaning of Tanks Lining of Storage Tanks Vent / Hatch Repair Tank Repair	Remove contamination from birds and insects. Remove accumulated sediment. Protect against tank wall corrosion. Prevent entry of vectors (e.g., birds, etc.)
Implementation or Upgrade of a Cross Connection Control and Backflow Prevention Program (Chapter 4.2.7)	Prevent flow of non-potable substances into the distribution system.
Sampler Training (Chapter 4.2.8)	Reinforces proper sampling and sample handling procedures to obtain uncontaminated samples. Reduces errors in sampling results.
Addition or Upgrade of On-line Monitoring and Control (Chapter 4.2.9) Water Quality Monitoring & Control Pressure Monitoring & Control	Automatically control and monitor disinfectant dosages and water quality parameters (other than total coliforms). Monitor pressure levels to identify physical problems in the system (e.g., pipe breaks, leaking valves, etc.).
Addition of Security Measures (Chapter 4.2.10)	Monitor potential locations for vandalism or security breaches that could lead to water contamination. Increase public confidence in protection of their drinking water.
Development and Implementation of an Operations Plan (Chapter 4.2.11) Develop Standard Operating Procedures (SOPs) Develop a Sampling Plan Perform Routine Inspections Develop an Emergency Response Plan Ensure the availability of appropriately qualified operators	Integrate all operations and maintenance functions to meet flow, pressure, and water quality goals. Establish a routine distribution system sampling plan. Implement an inspection and maintenance program to reduce sanitary defects. Define an emergency response plan for the distribution system to reduce reaction time and minimize confusion in emergencies. Ensure around-the-clock responsiveness.

4.2.1 Disinfection

Many systems use disinfection (by applying either temporary disinfection, shock chlorination, or booster disinfection) as a response to positive coliform results. It is also commonly used as a precautionary measure, especially when the cause of a positive coliform sample has not been identified, to help mitigate any potential contamination that could be present in the system. If a system is found to have contamination that requires a long term solution, it may take time for the system to design and install a corrective action. In the meantime, the system cannot serve the contaminated water to its customers. The primacy agency may require the system, as part of its corrective action, to apply chlorination until the contamination is eliminated or a corrective action is put in place. When temporary chlorination is applied in response to a coliform occurrence, the system should notify the State Chlorination should be kept in place until the State has reviewed the situation and has determined if the contamination has been addressed and the temporary disinfection can be suspended or if the disinfection needs to be continued.

Temporary disinfection can be conducted at the point of entry to the distribution system or can be installed at a location in the distribution system to target a specific area. Depending on the extent of the problem revealed by the Level 1 or Level 2 assessment, system-wide or targeted disinfection (such as shock chlorination) may be an appropriate corrective action.

For non-disinfecting systems or those using free chlorine, temporary/additional disinfectant in the form of sodium hypochlorite (bleach) is often used because it is easier to install and operate than gaseous chlorination or other disinfection methods, particularly on a temporary basis. It is a low cost option that can provide some protection to a portion of a distribution system or across an entire pipe network. However, care should be used in the storage of hypochlorite as age and temperature have been shown to be associated with the conversion of hypochlorite to perchlorate (Stanford et al. 2009).

It is important to note that temporary disinfection is better suited to deal with a single event and is not intended to deal with a chronic problem like source water contamination. Systems using chloramine as a secondary disinfectant should carefully balance chlorine addition with ammonia to maintain the desired chlorine to ammonia ratio for optimal chloramine formation.

Booster disinfection facilities located throughout a distribution system can provide additional chemical treatment in the system. Booster disinfection can improve or maintain disinfectant residual levels in a distribution system. Prior to discharge into the distribution system, potable water from a treatment facility must have a certain disinfectant residual level to minimize microbial growth. These levels are defined by State and Federal government regulations. Organics and reduced metals in the water also consume disinfectant residuals; therefore, it is vital to maintain an appropriate disinfectant residual level in the system in order to avoid increased levels of total coliforms in the system.

See Chapter 4.4 of this document for a discussion of simultaneous compliance issues systems should consider when using disinfection as a corrective action.

4.2.2 Flushing

A water main flushing program helps to keep the system clean and free of sediment, can reduce the disinfectant demand of pipe surfaces, and removes stagnant water and untreated or contaminated water that may have entered the system (Kirmeyer and Friedman 2000). Flushing can also be used to address water quality deterioration at dead-ends. The volume of water flushed is related to the length of flushing time and flow rate from the hydrant. Water systems should flush until a disinfectant residual can be measured or some other water quality target is reached (other than just until the water appears clear). A system could perform scheduled system-wide flushing, and/or periodic unscheduled (or "spot") flushing which can be used to address isolated water quality problems, including total coliform-positive samples. However, spot flushing should not be used as the only solution to positive coliform results or low residual events. Flushing should be used until the system identifies the source of the problem and a more permanent fix.

Upon obtaining a positive coliform sample, a common response is to flush the area near the sample site to draw in fresh water and remove any contaminated water that may be present. This unscheduled spot flushing is different from a routine flushing program in that the flushing only occurs when triggered by a water quality measurement, customer complaint, or similar event.

Minimum elements of a flushing scheduled/routine program are outlined in the AWWA G200 Standard (AWWA 2004) and include: (1) a preventive approach to address local problems or customer concerns and routine flushing to avoid water quality problems; (2) use of an appropriate flushing velocity to address water quality concerns; and (3) written procedures for all elements of the flushing program including water quality monitoring, regulatory requirements and specific flushing procedures.

4.2.3 Replacement / Repair of Distribution System Components

Distribution system components and appurtenances such as valves, pipes, fittings, hydrants, meters, and sample taps are integral parts of a water system. These components are also potential sources of contamination if improper installation or material degradation allows leaks or other entry points for contamination into a distribution system. Inspection of components may indicate that they should be replaced or repaired as part of proper maintenance, whether or not it is identified as the cause of the leak or as a possible entry point for contamination. Some components throughout the distribution system are located below grade, making a leak difficult to locate. However, a number of technologies have been developed to locate leaks below grade. Any repairs or replacements should be completed with proper attention to prevent contamination of the distribution system. See the AWWA standards listed in Chapter 4.5 of this document for more information on installation, repair, and replacement of distribution system components.

Valves

Valves are located throughout a distribution system to isolate portions of the system as needed. Leaks at the connection points between the valve and the adjacent pipe, as well as a valve seat or valve body, can create a pathway for contamination.

Water Mains

The condition of distribution system piping can be vital to the quality of water being conveyed to a community. Contaminants may enter through holes, breaks, cracks or joints in the piping. The condition of a pipe can vary based on type, age, and location of the pipe. Depending on the condition of the pipe, the water main can be replaced or repaired to stop infiltration into the system.

Fittings

There are many types of fittings located throughout a distribution system. The most common type of distribution system fitting is a cross. A cross has four connections which make it more susceptible to leaks. Leaks can occur because of a crack on the fitting or through the gasket between the fitting and another appurtenance, e.g., a valve, cap, or pipe.

Hydrants

Hydrants are located throughout a distribution system to provide potable water at required fire flow pressures for emergency situations. Hydrant connections are tapped off the distribution system; therefore, these connections can be possible locations for coliform contamination to enter a distribution system. Replacing a damaged or faulty fire hydrant can help eliminate sources of contamination into the distribution system as it eliminates a pathway for contamination. Systems should attempt to control usage of the hydrants as much as possible to eliminate unauthorized usa and install backflow prevention devices where possible.

Meters

Meters are located at entry points to commercial, residential, and industrial facilities to measure the amount of water that is consumed at a particular location. Sizes for each of the meters will vary based on the type and usage requirements of a facility. Contamination may enter through the connection points of the meter and the distribution system. Replacing a broken or faulty meter can help prevent contamination of the distribution system through leaks, as it eliminates a pathway for contamination.

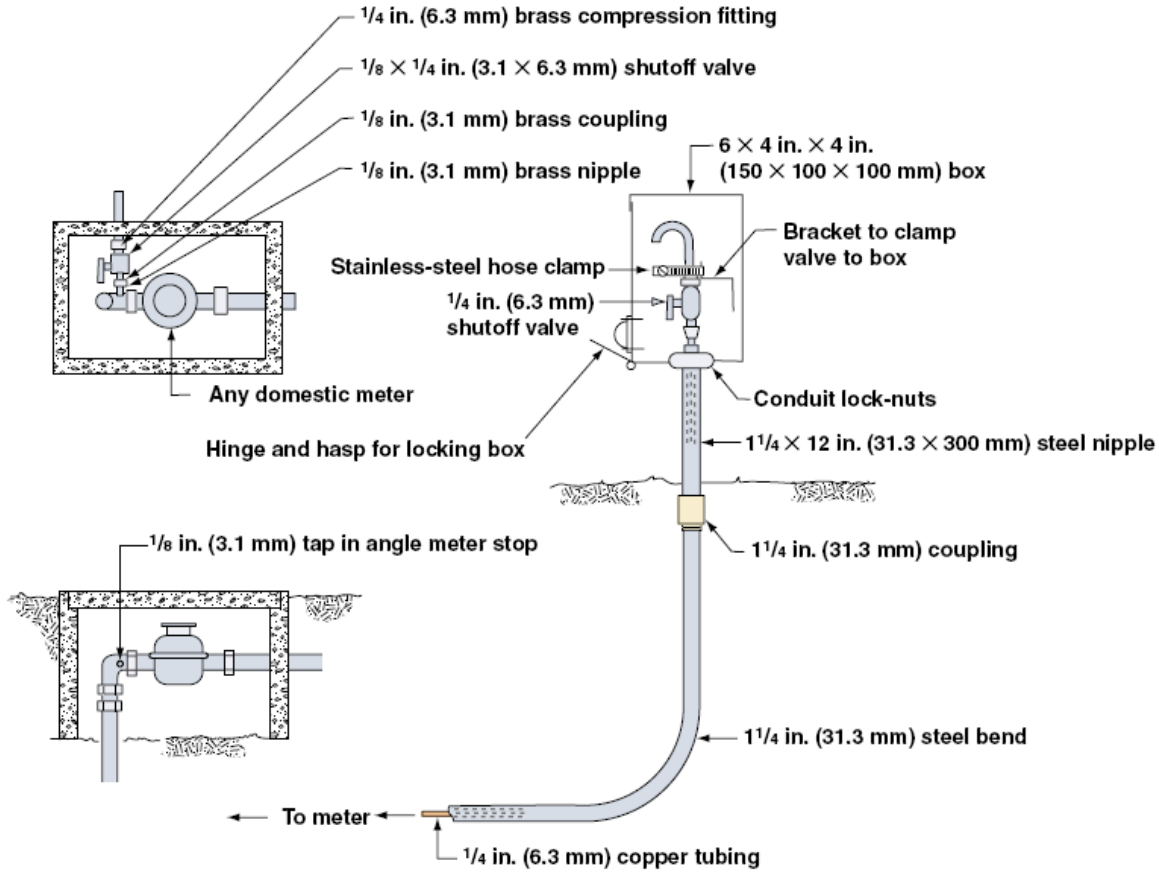
Dedicated Sample Taps

Typical sample locations often include both customer taps and dedicated sampling stations. A dedicated sampling station is a device that is plumbed directly into a distribution system line to provide "improved access to the distribution system water and provide reproducible samples that are representative of water quality at the customer's meter" (Kirmeyer and Friedman 2000). Installing dedicated sample taps can therefore minimize the occurrence of contamination that can result from improper sampling practices and minimize concerns about water quality in customer plumbing.

Dedicated sampling stations should be of metal construction, have unthreaded nozzles or a design approved by the State, and be located so as to be representative of the water in the distribution system. They are typically covered to protect them from birds, insects, dirt and other sources of outside contamination. Freezing of dedicated sampling taps has occurred in northern climates and that possibility should be considered when deciding whether and how to install such

taps. Figure 4-1 is a graphic schematic detailing the components of a dedicated sampling station. Figure 4-2 is a photograph of a dedicated sampling station.

Additional guidance on selection of an appropriate sample tap, including factors such as type of tap and sink, can be found in Narasimhan et al. 2004.



Source: Water Distribution System Operation and Maintenance, A Field Study Training Program. USEPA Office of Drinking Water and California Department of Health Services, Sanitary Engineering Branch. Hornet Foundation Inc., Sacramento, Calif. (1989, 2nd ed.).

Figure 4.1: Dedicated Sampling Station Schematic

Source: With permission courtesy of Koraleen Enterprises.

Figure 4.2: Dedicated Sampling Station

4.2.4 Maintenance of Adequate Pressure

Pressure losses can occur in the distribution system as a result of events such as flushing, main breaks, power outages, service line breaks, and fires. Pressure transients (also called pressure surges or water hammer) can occur when an abrupt change in water velocity occurs due to a sudden valve closure, pump shutdown or startup, or loss of power. The resulting pressure wave, with alternating low and high pressures, travels back and forth through the distribution system until the pressure is stabilized. Low pressure conditions in the distribution system can allow a flow reversal or backflow of non-potable water to enter the system from a cross connection or other source such as intrusion. Pressure transients can also create hydraulic disturbances that allow biofilm material on pipe surfaces to enter the bulk water. Systems should check with their State regarding distribution system pressure requirements. Industry guidelines suggest that system pressure should be maintained within the range of 35 to 100 psi at all points in the distribution system (AWWA 1996). The AWWA G200 standard indicates that the minimum residual pressure at the service connection under all operating conditions should be greater than 20 psi (AWWA 2004). Many states also have guidelines regarding distribution system operating pressure. Written standard operating procedures for pump, hydrant and valve operation under routine and emergency conditions can help minimize sudden changes in water velocity that impact system pressure.

Other actions that can help to maintain an adequate pressure in the distribution system include building new booster pump stations and elevated storage facilities, modifying existing high services pumps, and installing variable frequency drives, surge relief valves, and surge tanks.

Booster Pumping Stations

Booster pumping stations are used in the distribution systems to move water from lower pressure zones to higher pressure zones and to maintain pressure at desirable levels. As the

water system grows and changes, existing booster pump stations may no longer be able to maintain the desired pressure across the distribution system. In those cases, the construction of a new booster station may be required. The construction of a completely new booster pump station is not always required to maintain an appropriate pressure in a water system. There may be situations where a modification or replacement of an existing pump is sufficient.

Variable Frequency Drive

A variable frequency drive (VFD), also called a variable speed drive, allows a booster pump to supply the required amount of flow based on system demand with a pressure set point to maintain constant system discharge pressure, controlled to within a few psi of an operator–adjustable system pressure set point. VFDs work with a system pressure transmitter to control the system pressure set point.

Elevated Storage Facilities

Elevated storage is provided within the distribution system to supply peak demand rates and equalize system pressures. In certain systems, elevated storage is more effective and economical than ground storage because by nature of its elevated location, pumping requirements may be reduced, and the storage can serve as a source of emergency supply since system pressure requirements can still be met temporarily when pumps are out of service. Elevated storage tanks are often sited in areas having the lowest system pressures during intervals of high water use. These areas are often those of greatest water demand or those farthest from pump stations. Elevated tanks are generally located at some distance from the pump station serving a distribution pressure level, but ideally are not placed outside of boundaries of the service area unless the facility can be located on a nearby hill. Elevated tanks are built on the highest available ground so as to minimize the required construction cost and the height requirements.

Surge Relief Valves

Surge relief valves provide pressure management by ejecting water out of a side orifice to prevent excessive high-pressure surges and can also be triggered to open on a downsurge in pressure in anticipation of an upsurge to follow. Surge relief valves must always be used with caution for they can make low-pressure conditions in a line worse than they would be without the valve.

Surge Tanks

The four common types of surge tanks include pneumatic or closed tanks, open standpipes (or air chambers), one-way surge tanks (allows water to flow only from the tank into the pipeline), and two-way surge tanks (allows flow to and from the tank). If water is stored in these tanks for long periods of time, the water may lose its disinfectant residual and microbial growth and other water quality problems may results. Proper operations and maintenance of surge tanks is required to prevent poor quality or contaminated water from entering the distribution system.

Hydropneumatic tank systems are a popular way to provide pressure control and stabilization in smaller water distribution systems; however, they are not typically used in larger

systems. A hydropneumatic tank system allows for fluctuations in water distribution system pressure, and a potential cushion against water hammer. The system also minimizes booster pump on-off cycles so that a recommended frequency of 10-15 cycles per hour can be maintained.

The pressure tank uses a compressed air head-space to maintain system pressure. As water system demand increases, water in the pressure tank discharges into the system and reduces the pressure tank's water level, which expands the air cushion above the water and decreases the tank air pressure. When the air reaches a determined set point, the air compressor comes on to recharge the air space and cycles off when the high pressure set point is met. If the water demand continues to increase, the booster pumps will cycle on at the low water level and replenish the water level in the pressure tank. The pressure tank must be sized correctly, because its size determines the frequency of pump cycling.

4.2.5 Maintenance of Appropriate Water Age, Hydraulic Residence Time, and Mixing

Water quality problems associated with increased water age include reduced disinfectant residual, increased microbial activity, nitrification, and/or taste and odor problems. As water travels through the distribution system, chlorine continues to react with natural organic matter (NOM) to form disinfection by-products (DBPs). Thus, increased water age can also lead to higher DBP concentrations. Water systems should develop an overall strategy to manage the water age in their distribution systems, while considering the need to have adequate storage for emergencies. Establishing a water age goal is system-specific depending on system design and operation, water demands, and water quality (e.g., DBP formation potential). In the US, the average distribution system retention time is 1.3 days and the average maximum retention time is 3.0 days based on a survey of 800 medium and large water utilities (AWWA and AwwaRF 1992). Water age can be controlled through a variety of techniques including management of finished water storage facilities, looping of dead-ends, and re-routing of water by changing valve settings. Additional guidance is provided in the AwwaRF report, *Managing Distribution System Retention Time to Improve Water Quality* (Brandt et al. 2004).

Looping Dead-Ends

Dead-end pipes often result in stagnant water conditions where water age increases, which can cause water quality problems. One of the solutions to address the stagnant water issue is looping of dead-ends. However, looping should be evaluated carefully on a case-by-case basis as it may not actually reduce the long detention times present in those areas.

Installing Appropriate Main Sizes

Most distribution systems have been designed to meet a minimum hydraulic capacity. Additional capacity is generally included at the design stage to accommodate for future growth or to allow more flexibility in the configuration of a distribution system network. A PWS may also have a policy to limit the number of different pipe diameters within the system in order to simplify construction and maintenance. Consequently, network pipes tend to be larger than is necessary to meet the daily demand from the network leading to increased retention time. Hence, there can be an option to replace mains with smaller diameter pipes but still maintain the required hydraulic capacity.

Installing Automated Flushing Devices

Automated flushing devices are used to purge accumulated sediments at low spots and dead-ends of pipelines at regular intervals, and to drain pipelines for repairs, maintenance, and inspection. These devices are best suited to rural networks in which security of the units and disposal of the water flushed is less problematic. An additional drawback of installing these devices is the volume and value of the wasted water may be unacceptable. However, in networks with long pipe runs terminating in dead-ends, there may be few viable alternatives to flushing for controlling retention time.

Storage Facility Modifications

Most storage facilities have been designed focusing more on quantity, cost, service life, appearance, and shape than on maintaining water quality. Water quality in storage facilities is affected by the mixing patterns that occur primarily during the filling cycle, the long term residence time, and the interaction between these two phenomena. Old water in stagnant zones can often have very high DBPs and low to no disinfectant residual. This water can be released into the system during periods of high demand. Increasing volume turnover reduces the average hydraulic residence time (HRT) in finished water storage facilities, thereby reducing DBP formation, loss of disinfectant, and microbial growth. Kirmeyer and Friedman (2000) recommend complete turnover every three to five days but suggest that water systems establish their own turnover goal based on system-specific needs and goals. Improving mixing in finished water storage facilities can help eliminate stagnant zones. Mixing can be improved by increasing inlet momentum, changing the inlet configuration, increasing the fill time, and by installing mixing devices within the storage facility.

It may be necessary to reduce the water volume in a storage tank or increase demand on the tank to achieve increased volume turnover. Decommissioning storage facilities may be an appropriate strategy to reduce water age if existing facilities are oversized and not needed for emergency conditions, fire protection, or for maintaining system pressure. A professional engineer should review system needs, system design, and operation to determine if the existing storage capacity and tank operation are appropriate.

<u>Inlet/outlet configuration</u>

Inlet and outlet configuration are critical in the development of proper mixing in a finished water storage facility. The inlet structure should be located and sized to disperse the jet into the storage facility as well as to maintain a jet sufficient for mixing. In particular, the location and orientation of the inlet pipe relative to the tank walls can have a significant impact on mixing characteristics. The physical modifications to the inlet pipe for improving mixing within the tanks include:

- Changing the orientation of the inlet pipe and/or
- Decreasing the inlet diameter to increase the jetting action.

The outflow configuration does not significantly influence mixing, but operation of the inlet and outflow are important because flow entering the tank and leaving the tank at the same

time can negatively impact mixing and should be avoided. Furthermore, when the inlet/outlet is a common pipe, the ability to reduce the inlet diameter to achieve a higher inflow velocity and better jetting action will be constrained by the need to maintain an outflow capacity adequate to satisfy system operational and fire flow requirements. For this reason, it is recommended to eliminate common inlet/outlet pipes.

Installation of mixing devices

Mixing the storage facility contents to reduce stagnant zones can also be accomplished by installing mixing devices. Special precautions are needed with mechanical mixing devices because of potential contamination to finished water by the mixer mechanism lubrication system. Multiple mixing devices may be needed and the PWS should consider the increased maintenance requirements inside the storage facility.

Increasing volume turnover

As mentioned earlier in this section, increasing the volume turnover reduces the average HRT in the storage tank. Turnover can be accomplished by making operational modifications to the storage tank such as increasing the water level fluctuation or drawdown between fill and draw cycles. The water level should be lowered in one continuous operation not in small incremental drops throughout the day.

Operational modifications may be limited by the following considerations:

- Control of flow rates during tank filling may be needed to minimize the potential for low pressure in the distribution system;
- Changes in operating protocol for booster stations and other tanks to achieve turnover while maintaining adequate pressure system-wide.

4.2.6 Maintenance of Storage Facility

Finished water storage tanks are an important component of a PWS's distribution system. Tanks are usually designed for three purposes: reduce pressure fluctuations in the distribution system, equalize water demands, and provide water reserves for emergencies such as fires and power outages.

The two main categories of water storage tanks include ground storage tanks and elevated storage tanks (see previous discussion on elevated storage tanks in Chapter 4.2.5). Ground storage tanks can be below grade, partially below grade, or at ground level in a distribution system and are usually constructed of a variety of materials, including steel, concrete, and fiberglass reinforced plastic. Elevated storage tanks are typically constructed of steel.

Contamination from birds and insects can be a source of microbial contamination in the distribution system. Maintenance on a storage tank can significantly reduce the possibility of contamination or recontamination. Some actions include inspecting and cleaning, lining the interior of the tank, repairing vents and/or hatches, and repairing the tank itself.

Inspection / Cleaning of Tanks

Tank inspections can provide useful information on the physical condition of the exterior and interior of the tank, identifying potential sources of microbial contamination. Inspections can also identify the accumulation of sediment within storage tanks due to particle settling in the tank or the dissolving of cementitious materials of a concrete tank from soft, low alkalinity, low pH waters. There are several water quality issues associated with sediment buildup in a storage tank, including increased disinfection demand, microbial growth, disinfection by-product formation, and increased turbidity.

Lining of Storage Tanks

Lining the interior of a water storage tank is another action that can be taken to reduce the potential for coliform contamination and recontamination of a distribution system. Corrosion and corrosion product buildup from excessive interior corrosion can also result in water quality issues such as increased disinfection demand, microbial growth, and increased turbidity.

Vent / Hatch Repair

One of the most common sources of contamination in a water storage tank is the improper design and maintenance of vents and roof hatches. These accessories can provide entry points for debris as well as microbial contamination from birds and insects. Aging water storage tanks with damaged tank covers can also be a source of microbial contamination. To prevent contamination and recontamination of the water supply, damaged vents, hatch roofs, and tank covers should be repaired or replaced immediately.

Tank Repair

Aging water storage tanks can provide entry points for debris as well as microbial contamination from birds and insects and should be replaced or repaired immediately to prevent contamination and recontamination of the water supply.

4.2.7 Implementation or Upgrade of a Cross-connection Control and Backflow Prevention Program

Implementing a Cross-connection Control and Backflow Prevention (CCCBFP) Program, including the installation of backflow prevention assemblies and devices, can prevent the flow of non-potable substances into the distribution system. When implementing the CCCBFP Program, the drinking water system should adhere to applicable State and/or local criteria, codes, and/or regulations. Some codes or regulations may include documenting installation procedures and the periodic testing of backflow prevention assemblies. CCCBFP can prevent the introduction of non-potable substances into the public water supply due to backsiphonage or backpressure.

Backflow prevention equipment installation and maintenance is generally the consumer's responsibility. However, depending on how a system implements the CCCBFP, the customer and the PWS can share costs for the equipment and equipment installation, inspection, testing, and maintenance. The PWS, on the other hand, is primarily responsible for the administration of cross-connection control and backflow prevention and the inspection, review, and approval of all backflow prevention assemblies and devices.

4.2.8 Sampler Training

Implementation of a sampler training program provides guidelines for procedures that samplers must follow to collect valid, uncontaminated samples for analysis of total coliforms in the distribution system. Training sessions for operators reinforce proper sampling and sample handling procedures to obtain uncontaminated samples.

4.2.9 Addition or Upgrade of On-line Monitoring and Control

Currently, monitoring of total coliforms is performed through grab samples at the treatment plant and throughout the distribution system. These grab samples are then analyzed in a laboratory to determine whether total coliforms are present or not in the grab sample. To ensure sufficient treatment has been provided, grab sample results, disinfectant dosages, and certain water quality parameters, such as disinfectant residual levels, can be correlated. Since automatic monitoring is not available for total coliforms, PWSs can instead automatically control and monitor for disinfectant dosages and water quality parameters.

Water Quality Monitoring and Control

The ability of a PWS to monitor disinfectant residuals in the distribution system can allow the PWS to determine if there is an area of possible contamination or an area that requires additional treatment. Low levels of disinfectant residuals in a system can be caused by an increase of organics in a system, which consume disinfectant residuals, or insufficient disinfectant dosages at the treatment facility. Maintenance of sufficient disinfectant residual levels in a distribution system is important in maintaining minimal levels of total coliforms in the system.

Disinfectant residual can be monitored using routine grab samples, with adjustment of dosages based on results. Controlling and monitoring disinfectant dosages and water quality parameters can also be performed through the use of a Supervisory Control and Data Acquisition (SCADA) system at the treatment facility. Disinfectant dosing equipment can be monitored and analyzers can be placed in the treatment process to monitor water quality parameters. Monitoring water quality parameters via SCADA in a distribution system is possible; however, it can be costly. Determining the number and location of the analyzers is challenging and highly dependent upon the system size. Typically, analyzer equipment will draw samples from an above grade pipe or a sample tap to an analyzer that is placed in a building. Sample locations will require analyzer equipment, a building, electric power, and, in the case of some systems, integration to the PWS's existing SCADA system. Method requirements for on-line amperometric chlorine monitors are more time intensive and difficult than grab sampling.

Pressure Monitoring and Control

In addition to water quality monitoring, a PWS can monitor pressure levels throughout the distribution system. Installing online pressure monitoring and control will help minimize future incidents of pressure loss that can allow entry of contaminants into the distribution system. It can also help determine if there are any physical problems in the system, e.g., a crack in a pipe, a leaking valve, etc., that cause changes to the water quality of the system. Pressure readings can also be used to help locate areas of deficiency in a distribution system. Similar to the water quality monitoring, determining the number of pressure monitors and their locations is dependent

upon the system size. Pressure monitoring locations will also require the same equipment as water quality sampling locations.

On-line distribution system monitoring through the SCADA system can alert operators if there are possible issues with the distribution system; however, monitoring the water quality or pressure will not identify the source of the contamination nor will it necessarily identify the location of the contamination.

4.2.10 Addition of Security Measures

Systems may need to install security measures in circumstances where the assessment or onsite inspection reveals vandalism or security breaches that could lead to water contamination. Measures that a water system may take to correct security breaches include installing a fence or locking buildings to restrict access to the system. Other possible security measures include employing a full time, on-site security staff and using alarms and cameras to detect security breaches.

Water systems should prioritize their security measures and concentrate on the most vulnerable parts of the system, such as unstaffed facilities (e.g., finished water storage tanks). An important implementation issue is determining the extent to which the water system needs to be secured. This would depend on how widely spread the system/facility is, the number and complexity of the treatment trains, the extent of the watershed, the distance of the treatment plant from the influent wells, accessibility of the distribution system, etc.

Installing security measures can increase the public's confidence in the protection of their drinking water and indeed can provide substantial protection against vandalism that might result in contamination of the water. However, security measures are not always foolproof or absolute in combating vandalism or security breaches.

4.2.11 Development and Implementation of an Operations Plan

A water system should develop a distribution system operations plan to integrate all operations and maintenance functions to meet the goals of flow, pressure and water quality. The AWWA G200-04 standard describes the critical requirements for the effective operation and management of drinking water distribution systems. According to this standard, a water system should develop standard operating procedures (SOPs), comprehensive monitoring plans, routine inspections, and emergency response plans.

Develop Standard Operating Procedures (SOPs)

SOPs should be developed for each operation and maintenance function that affects system water quality (e.g., flushing programs, storage facility inspections). The water quality goals for both the distribution system and the particular function should be specified in the SOP. SOPs should be developed from information gathered from the various departments and crews involved in a given function. The SOPs should be written in terms that everybody will understand and they should include all activities needed to conduct the procedures, and describe the labor, equipment and materials needed to complete the activity.

Develop Sampling Plan

The water system should establish a routine distribution system sampling plan that is representative of the entire distribution system. At a minimum, the sample sites should include sites required for regulatory compliance monitoring. Additional sites should be sampled as necessary to provide a complete picture of the water quality in the system. All samples should be collected in accordance with the latest edition of *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 2005).

Perform Routine Inspections

Routine inspections of various distribution system components such as finished water storage facilities, water mains, pump stations, chemical storage facilities, valves, and fire hydrants are necessary to ensure high-quality water. The water systems should implement inspection and maintenance programs of these components as part of the SOPs.

Develop Emergency Response Plan

A written emergency response plan for the distribution system allows operating personnel to respond efficiently, effectively and rapidly to an emergency situation. Water quality system safety and reliability are improved if a water system has an emergency response plan.

Utilize Appropriately Qualified Operators

EPA established an operator certification program with minimum professional standards for the operation and maintenance of water systems. The EPA program issued guidelines that specify standards for certification and recertification of operators. States implement the minimum standards of the certification program guidelines. While the specific requirements vary from state to state, the goal of the program is to ensure that skilled professionals are overseeing the treatment and distribution of safe drinking water and compliance with the Safe Drinking Water Act. More information on the operator certification program can be found at: *http://www.epa.gov/safewater/operatorcertification/index.html*.

Providing training sessions for operators reinforce proper operation and maintenance of these facilities and systems. These sessions can also help educate PWS staff on emerging treatment technologies, regulatory requirements, and other advances in the drinking water industry.

4.3 Best Practices

Best practices are actions that systems should and/or might choose to take following a Level 1 or Level 2 trigger regardless of whether a sanitary defect or likely cause is identified, or following any total coliform or *E. coli* occurrence (e.g., a single *E. coli*-positive sample). They can range from temporary measures to long term measures.

In the survey conducted by AWWA, AMWA, ASDWA (see footnote 8), most respondents indicated that follow-up actions are taken following a positive coliform result even when the underlying cause is unidentified. Systems take these actions to ensure public health protection and generally do not involve major construction or capital improvement. Examples of common actions that were reported are flushing, increasing disinfectant residual, collecting

additional investigative samples, examining whether samples were collected from appropriate sample sites, and re-training staff/sampler on proper sampling procedures. Based on the results of the survey, the list below includes these actions and a few other ones as examples of best practices that systems may take following an assessment trigger or a positive coliform result, regardless of whether the cause or the sanitary defect is identified. Some of them have already been discussed in Chapter 4.2 of this document. These actions are not mutually exclusive and systems may choose to implement a combination of them if appropriate. Systems should also consider implications for long-term sustainability and public health protection when deciding which of these actions to implement.

The proposed RTCR also identifies a list of "best technologies, treatment techniques, or other means" (also known as best available technologies or BATs) to help systems comply with the rule (see §141.63(e) of the proposed RTCR). They include appropriate well placement and construction, maintenance of a disinfectant residual throughout the distribution system, proper maintenance of the distribution system, filtration and disinfection of surface water, implementation of a cross-connection control program, and implementation of a wellhead protection program. Systems may choose to take advantage of these BATs when they trigger an assessment in order to avoid future triggers and/or violations, even if they are unable to find a likely cause/sanitary defect. Some of these BATs are also discussed in the list below.

- *Apply disinfection* – A discussion of disinfection practices is in Chapter 4.2.1 of this document. Additional information on emergency disinfection practices can be found at *http://www.epa.gov/safewater/faq/emerg.html*

- *Change or update distribution system maintenance operations* – A well-maintained and operated distribution system is an important barrier in protecting water quality. Even if water from an extremely clean source is adequately treated, breakdowns in the distribution system can lead to waterborne illnesses. In particular, the contamination of treated water can result from main breaks, inadequate water pressure that allows intrusion or backflow of contaminants, deficiencies in storage tanks, and inadequate separation of water supply lines and sewers.

  Proper maintenance of the distribution system includes appropriate pipe replacement and repair procedures, main flushing programs, proper operation and maintenance of storage tanks and reservoirs, cross-connection control, and continual maintenance of positive water pressure in all parts of the distribution system. Even if a Level 1 or Level 2 assessment does not reveal an underlying cause for the positive coliform samples, many systems may choose to change or update their distribution system maintenance operations as a follow-up action. Many of these actions are described in Chapters 4.2.3 to 4.2.7 of this document.

- *Perform unscheduled or spot flushing* – A discussion of unscheduled or spot flushing is in Chapter 4.2.2 of this document.

- *Implement sampler training* – A discussion of sampler training is in Chapter 4.2.8 of this document.

- *Review sample siting plan* – The sample siting plan should ensure that the quality of the water is representative of the distribution system. Utilities might consider reviewing and revising their sample siting plan as a universal follow-up action, regardless of whether an underlying cause for the positive coliform samples can be identified.

- *Select appropriate sample sites* – Part of a successful sampling plan is the selection of clean, appropriate sample taps and sites from which to collect representative samples. In addition to reviewing the sample siting plan, systems may wish to consider the use of dedicated sample taps, which is discussed in Chapter 4.2.3 of this document.

- *Institute boil water orders* – A number of systems have chosen to institute boil water orders even in cases where total coliforms are detected but no *E. coli* is present. In some States, boil water orders are a required follow-up action after a total coliform-positive sample has occurred. However, it should be noted that requirements vary from state to state and systems should follow State requirements for implementing boil water orders, whether they are required in response to a total coliform-positive or not.

  A boil water order requires that systems publicly advertise that water should be boiled prior to consumption. While a boil water order can be protective of public health, it also requires effort for consumers, has economic impacts to businesses, and can undermine public confidence in the water supply. Therefore a boil water order should not be implemented lightly and should be reserved for situations with significant potential to impact public health. A Level 2 trigger associated with an *E. coli*-positive may be more appropriate for a boil water order action than a Level 1 trigger associated with a total coliform-positive. Boil water orders may also be issued on a voluntary basis and may be helpful for educating sensitive populations.

4.4 Simultaneous Compliance Issues

As mentioned previously, the interrelated nature of regulations can be a challenge as adjustments to improve compliance for one rule may inadvertently affect a system's ability to comply with another rule. Given that temporary disinfection is a common corrective action taken by systems that have experienced positive coliform results, a number of related issues are important to keep in mind.

NTNCWSs and CWSs that do not typically practice disinfection and are planning on adding temporary disinfection are subject to the Stage 1 and Stage 2 Disinfectants/Disinfection By-Products Rules (DBPRs) (40 CFR 141.130 and 141.600) (USEPA 1998b; USEPA 2006a) for the monitoring period in which the disinfectant is used. Systems should check with their States to determine what the requirements are for compliance with the rules. For temporary disinfection by chlorine or chloramines, the system will have to ensure that maximum residual disinfectant levels (MRDLs) for chlorine/chloramines and maximum contaminant levels (MCLs) for total trihalomethanes (TTHM) and the group of five haloacetic acids (HAA5) are not exceeded.

Alkalinity and pH adjustment and/or the addition of corrosion inhibitors are often used to meet Lead and Copper Rule (LCR) (40 CFR Part 141, Subpart I) requirements. Systems that are using measures such as these should also be aware that the pH of the water can alter the efficacy of the disinfectant. For a given level of inactivation, the higher the pH, the higher the

disinfection detention time and/or chlorine residual concentration required. See *Revised Guidance Manual for Selecting Lead and Copper Control Strategies* (USEPA 2003) for more information on simultaneous compliance with the LCR and other drinking water regulations.

Systems should also be aware that changes in disinfectant residual may alter the corrosivity of the water. Chlorine is a powerful oxidant and reacts with many metals that are present in the distribution system. Rapid changes between high concentrations and low (or no) concentrations of oxidants can destabilize metal scales that form along the pipe wall, possibly allowing for metal release into the water.

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Appendix A

Example Assessment Forms

The following are examples of Level 1 and Level 2 assessment forms developed by the Total Coliform Rule Distribution System Advisory Committee Technical Work Group.

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CONCEPT EXAMPLE
Level 1 Assessment Form

System Name:	Source Water:	PWSID #
System Type:	Population Served:	PWS Address:
Operator in Responsible Charge (ORC):	Phone:	
City, State:		
County:		
Person that collected TC samples if different than ORC:	Phone:	
Address, City, State, Zip:		
Date Assessment Completed:		

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples? -any interruptions in the treatment process -any reported loss of pressure events (pressure < 5 psi) -operation and maintenance activities that could have introduced total coliform -reported vandalism and/or unauthorized access to facilities -visible indicators of unsanitary conditions reported -any fire fighting event, flushing operation, sheared hydrant, etc. -any sites with low or inadequate disinfectant residual or sites where it is difficult to maintain a residual -any other water quality parameters measured where results were out of the ordinary				
2. Have there been any recent operational changes to the system? -sources introduced -treatment or operational changes -potential sources of contamination				
3. Evaluate sample site. -condition or location of tap -regular use of connection				
4. Sample protocol followed and reviewed. -flush tap -remove aerator -no swivel -fresh sample bottles -sample storage acceptable				
5. Distribution System -system pressure -cross connection -pump station -air relief valves -fire hydrants or blow off -breaks -repairs				

CONCEPT EXAMPLE
Level 1 Assessment Form

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
6. Storage Tank -screens -security -access opening -condition of tank -vent -drain overflow -pressure tank -O&M				
7. Treatment Process -interruptions -POE/POU -softeners -O&M				
8. Source - Well -sanitary seal -vent screened -air gap -cross connection -security -pump to waste line				
9. Source - Spring -condition of spring development -condition of spring box -security				
10. Source - Surface Water Supply -heavy rainfall -rapid snowmelt				

Note: Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

Print name of person completing form: Date:
Signature: _____

Reserved for State

1.	Assessment has been successfully completed.	
2.	Likely reason for total coliform-positive occurrence is established.	
3.	System has corrected the problem.	
4.	Was a reset requested and / or granted? – Rationale	
5.	Name of State reviewer:	

CONCEPT EXAMPLE
Level 2 Assessment Form

System Name:	Source Water:	PWSID #
System Type:	Population Served:	PWS Address:
Operator in Responsible Charge (ORC):	Phone:	
City, State:		
County:		
Person that collected TC samples if different than ORC:	Phone:	
Address, City, State, Zip:		
Date Assessment Completed:		

Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples?				
a. Were there any operation and maintenance activities that could have introduced total coliforms?				
b. Have there been any interruptions in the treatment process?				
c. Has the system lost pressure to less than 5 psi?				
d. Have there been any vandalism and/or unauthorized access to facilities?				
e. Are there any visible indicators of unsanitary conditions observed?				
f. Have there been any analytical results or any additional samples collected, including source samples which were positive (not for compliance)?				
g. Have there been any sites with low or inadequate disinfectant residual? Are there sites where it is difficult to maintain a residual without flushing?				
h. Were any other water quality parameters measured and were any results out of the ordinary?				
i. Have there been any community illness suspected of being waterborne (e.g., Does the community public health official indicate that an outbreak has occurred.)				
j. Did the water system receive any TCR monitoring violations in the past 12 months? If yes, when.				
k. What was the most recent date on which satisfactory total coliform samples were taken?	Date: _____			
l. Have there been a fire fighting event, flushing operation, sheared hydrant, etc.				
m. Other comments on records and maintenance?				

CONCEPT EXAMPLE
Level 2 Assessment Form

Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
2. Have there been any recent treatment or operational changes?				
a. Have any inactive sources recently been introduced into the system (e.g., auxiliary systems)?				
b. Have there been any new sources introduced into the system?				
c. Is there evidence of any potential sources of contamination (main breaks, low pressure, high turbidity, loss of disinfection, etc.)?				
3. Evaluate sample site				
a. What is the condition of the tap? **(Provide comments)**				
b. What is the location of the tap? **(Provide comments)**				
c. What is the regular use of the connection? **(Provide comments)**				
d. Have there been any plumbing changes or construction? If yes, when and what was the repair or change?				
e. Have there been any plumbing breaks or failure? If yes, when?				
f. List any identified cross connections after the service connection or in premise plumbing. **(Provide comments)**				
g. Were all of the backflow prevention devices present, operational and maintained?				
h. Were there any low pressure events or changes in water pressure after the service connection or in the premise plumbing? If yes, when?				
i. Is there any treatment devices after the service connection or in premise? **(Circle response, if applicable)**	. Point of Entry (POE) Point of Use (POU)			
j. Other comments on sample site?				
4. Sample protocol followed and reviewed				
a. Flush tap, remove aerator, no swivel, fresh sample bottles, sample storage acceptable				
5. Distribution System				
a. System pressure: Is there evidence that the system experienced low or negative pressure? If yes, when?				
b. List any identified cross connections.				
c. Pump station: Are there any sanitary defects in the pump station? Are pump(s) operable?				

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
d.	Last pump maintenance/service date. **(Respond if applicable)**	Date: _____		Maintenance Performed?	
e.	Air relief valves: Is the valve vault subject to flooding or does the vent terminate below grade?				
f.	Fire hydrant/blow off: Are any located in an area with a high water table or pits?				
g.	Is the distribution system secured to prevent unauthorized access?				
h.	Are the backflow prevention devices at high risk sites present, operational and maintained?				
i.	Have there been any water main repairs or additions? If yes when, and what was the repair or addition?				
j.	Have there been any water main breaks? If yes, when?				
k.	Was there any scheduled flushing of the distribution system? If yes, when?				
l.	Is there any evidence of intentional contamination in the distribution system?				
m.	Other comments on the distribution information.				
6. Storage Facilities					
a.	Are the overflow and vents properly screened?				
b.	Is the facility secured to prevent unauthorized access?				
c.	Does the access opening have the proper gasket and seal tightly?				
d.	Could the physical condition of tank be a source of contamination?				
e.	Is the vent turned down and maintaining an approved air gap at the termination point?				
f.	Does the drain/overflow line terminate at a minimum of 12" air gap?				
g.	If present, is the pressure tank maintaining an appropriate minimum pressure?				
h.	Has proper O&M been performed?				
i.	Was there any observed physical deterioration of the tank?				
j.	Were there any observed leaks?				
k.	Is there any evidence of intentional contamination at the storage tank?				
l.	Has there been any facility maintenance (i.e. painting/coating)? If yes, when?				

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
m.	Is facility maintenance occurring per appropriate schedule?				
n.	Does the tank "float" on the distribution system or are there separate inlet and outlet lines?				
o.	What is the measured chlorine residual (total/free) of the water exiting the storage tank today?	Residual _____			
p.	Are there any unsealed openings in the storage facility such as access doors, vents or joints?				
q.	Other comments on the storage system				
7. Treatment Process. (If applicable)					
a.	Treatment devices operational and maintained?				
b.	Is there any recent installation or repair of treatment equipment?				
c.	Were there any recent changes in the treatment process (e.g., addition of a process, change in chemical or dosage)? If yes, when, what was the change?				
d.	Were there any interruptions of treatment (lapses in chemical feed, turbidity excursions, disinfection)? If yes which part, when and for how long?				
e.	What is the free chlorine residual measured immediately downstream from the point of application?	Residual: _____			
f.	Did a review of the filter turbidity profiles reveal any anomalies?				
g.	Were there any failures to meet the C x T calculations?				
h.	Were the flow rates above the rated capacity?				
i.	Were there any anomalies on the settled water turbidities?				
j.	Other comments on the treatment system.				
8. Source – Well					
a.	Is the sanitary seal intact?				
b.	Is the vent screened?				
c.	Does the vent and pump to waste terminate in an approved air gap?				
d.	Are there any unprotected cross connections at the wellhead?				
e.	How is the well used? **(Circle if applicable)**	Primary Backup Emergency Not a PWS Not Drinking Water			
f.	How far does the casing extend above grade?	Height _____		Comments:	

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
g.	Is the well cap vented?				
h.	Is there evidence of standing water near the wellhead?				
i.	Is the wellhead secured to prevent unauthorized access?				
j.	Have there been any sewer spills, source water spills or other disturbances?				
k.	Other comments on the well system. (Are there aspects of well construction and operation that would bear on observed positives?)				
9. Source – Spring					
a.	What is the condition of the spring development?				
b.	What is the condition of the spring box?				
c.	Is the spring secured to prevent unauthorized access?				
d.	Other comments on the spring system.				
10. Source - Surface Water Supply					
a.	Have there been any sewer spills, source water spills or other disturbances?				
b.	Have there been any algal blooms?				
c.	Has source water turnover occurred?				
d.	Other source water comments				
Environmental Events					
a.	Has there been heavy rainfall?				
b.	Has there been any rapid snow melt or flooding?				
c.	Have there been changes in available source water (e.g., significant drop in water table, well levels, reservoir capacity, etc.)				
d.	Have there been any interruptions to electrical power?				
e.	Have there been any extremes in heat or cold?				

Note : Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

CONCEPT EXAMPLE
Level 2 Assessment Form

Print name of person completing form: Date:
Signature: _____

Reserved for State

1. Assessment has been successfully completed. ☐ Name of State Reviewer: _____

Appendix B

Examples of Completed Assessments

This appendix provides examples of completed Level 1 and Level 2 assessment forms (using the forms presented in Appendix A). Some States are already requiring some form of assessment and the completion of an assessment form whenever a PWS has a total coliform-positive sample. Those States provided EPA with some of the completed assessments performed by their respective PWSs. EPA developed the examples in this appendix based on the assessment forms provided by the States. Personal information about the PWS or any person mentioned in the example forms is fictitious in nature. They are provided to show the types of information that are expected to be included in the form.

Assessment Form Instructions

1. Fill in system information under the first section of the form. The following information must be provided at a minimum:
   - System Name
   - Source Water (GW, SW, GWUDI, Purchased)
   - System Type (CWS, NTNCWS, TNCWS)
   - Population Served
   - Operator in Responsible Charge (ORC)
   - Phone
   - City, State
   - PWSID #
   - PWS Address

2. Respond to all Questions 1-10:
   - Type "✓" in the box for the items that were reviewed and checked or "N/A" if the item is not applicable to the system.
   - Print "Yes" or "No" in the "Issue(s) found?" column.
   - Describe any issues found and corrective action taken.
   - Be sure to include dates of any corrective actions taken.

3. Sign and date form on last page. Form must be completed based on data and documents available to the PWS operator in charge, maintained on file, and sent to the primacy agency within XX days.

Example No. 1 – Level 1 Assessment

UTILITY PROFILE
Buttermilk Falls Country Club is a non-transient, non-community water system that gets its water from a ground water source. It collects 1 routine sample per month. The system does not have any records of past violations.

DESCRIPTION OF THE PROBLEM
In November 2009, the routine monthly sample and one of its associated repeat samples came back positive for total coliforms. This triggered a Level 1 assessment.

ASSESSMENT AND CORRECTIVE ACTION
All applicable items listed in the Level 1 assessment form were all checked. Nothing unusual was found and all of the subsequent repeat samples came back negative.

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CONCEPT EXAMPLE NO. 1
Level 1 Assessment Form

System Name: **Buttermilk Falls Country Club**	Source Water: **Ground Water**	PWSID # **1234567**
System Type: **NTNCWS**	Population Served: **120**	PWS Address:
Operator in Responsible Charge (ORC): **J. Griffin**	Phone: **012-345-6789**	**123 Anyway St., Buttermilk Falls, MS 10000**
City, State: **Buttermilk Falls, MS**		
County: **Hoover**		
Person that collected TC samples if different than ORC: **C. Gary, HHH Labs**	Phone: **123-456-7890**	
Address, City, State, Zip: **222 Second St., Buttermilk Falls, MS 12121**		
Date Assessment Completed: **11/12/2009**		

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples? -any interruptions in the treatment process -any reported loss of pressure events (5 psi) -operation and maintenance activities that could have introduced total coliform -reported vandalism and/or unauthorized access to facilities -visible indicators of unsanitary conditions reported -Has there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**No**		
2. Have there been any recent operational changes to the system? -sources introduced -treatment or operational changes -potential sources of contamination	✓	**No**		
3. Evaluate sample site. -condition or location of tap -regular use of connection	✓	**No**		
4. Sample protocol followed and reviewed. -flush tap -remove aerator -no swivel -fresh sample bottles -sample storage acceptable	✓	**No**		
5. Distribution System -system pressure -cross connection -pump station -air relief valves -fire hydrants or blow off -breaks -repairs	✓	**No**		

CONCEPT EXAMPLE NO. 1
Level 1 Assessment Form

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
6. Storage Tank -screens -security -access opening -condition of tank -vent -drain overflow -pressure tank -O&M	**N/A**			
7. Treatment Process -interruptions -POE/POU -softeners -O&M	**N/A**			
8. Source - Well -sanitary seal -vent screened -air gap -cross connection -security -pump to waste line	✓	**No**		
9. Source - Spring -condition of spring development -condition of spring box -security	**N/A**			
10. Source - Surface Water Supply -heavy rainfall -rapid snowmelt	**N/A**			

Note: Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

At this time, the obvious cause of the total coliform-positive results has not been identified.

Print name of person completing form: **Betty Sutherland** Date: **11-12-09**

Signature: _____

Reserved for State

1.	Assessment has been successfully completed.	
2.	Likely reason for total coliform positive- occurrence is established.	
3.	System has corrected the problem.	
4.	Was a reset requested and / or granted? – Rationale	
5.	Name of State reviewer:	

Example No. 2 – Level 1 Assessment

UTILITY PROFILE
Silver Lake is a mid-sized community water system that supplies treated ground water to approximately 24,200 people. It collects 25 routine samples per month.

DESCRIPTION OF THE PROBLEM
The system received a notice of violation for failing to take all of the required repeat samples after a total coliform-positive sample was detected, triggering the system to have a Level 1 assessment.

ASSESSMENT AND CORRECTIVE ACTION
Upon thorough inspection of the distribution system, an air release valve was found submerged in a flooded valve vault. A permanent sump pump will be installed in the vault based on a schedule approved by the State. Shock chlorination measures were performed in accordance with State guidelines on the portion of the line where the air release valve was located.

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CONCEPT EXAMPLE NO. 2
Level 1 Assessment Form

System Name: **Silver Lake**	Source Water: **Ground Water**	PWSID # **2345671**
System Type: **CWS**	Population Served: **24,200**	PWS Address: **123 Anyway St., Silver Lake, MI 10000**
Operator in Responsible Charge (ORC): **J. Troy**	Phone: **012-345-6789**	
City, State: **Silver Lake, MI**		
County: **Hamilton**		
Person that collected TC samples if different than ORC: **B. Black, CDE Labs**	Phone: **123-456-7890**	
Address, City, State, Zip: **111 First St., Gold Water, MI 20000**		
Date Assessment Completed: **02/12/2010**		

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples? -any interruptions in the treatment process -any reported loss of pressure events (5 psi) -operation and maintenance activities that could have introduced total coliform -reported vandalism and/or unauthorized access to facilities -visible indicators of unsanitary conditions reported -Has there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**No**		
2. Have there been any recent operational changes to the system? -sources introduced -treatment or operational changes -potential sources of contamination	✓	**No**		
3. Evaluate sample site. -condition or location of tap -regular use of connection	✓	**No**		
4. Sample protocol followed and reviewed. -flush tap -remove aerator -no swivel -fresh sample bottles -sample storage acceptable	✓	**No**		
5. Distribution System -system pressure -cross connection -pump station -air relief valves -fire hydrants or blow off -breaks -repairs	✓	**Yes**	Visual inspection of distribution system conducted on 2/11/10 revealed a potential contamination source at end of distribution system. An air release valve was found submerged in a flooded vault.	Sump pump to be installed at potential contamination site on 2/20/10. State approved corrective action beyond the 30-day period. Shock chlorination performed in accordance with State guidelines on portion of water line where air valve is located.

CONCEPT EXAMPLE NO. 2
Level 1 Assessment Form

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
6. Storage Tank -screens -security -access opening -condition of tank -vent -drain overflow -pressure tank -O&M	✓	**No**		
7. Treatment Process -interruptions -POE/POU -softeners -O&M	✓	**No**		
8. Source - Well -sanitary seal -vent screened -air gap -cross connection -security -pump to waste line	✓	**No**		
9. Source - Spring -condition of spring development -condition of spring box -security	**N/A**			
10. Source - Surface Water Supply -heavy rainfall -rapid snowmelt	**N/A**			

Note: Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

Print name of person completing form: **Adam Lockland** Date: **02-12-2010**
Signature: _____

Reserved for State

1.	Assessment has been successfully completed.	
2.	Likely reason for total coliform-positive occurrence is established.	
3.	System has corrected the problem.	
4.	Was a reset requested and / or granted? – Rationale	
5.	Name of State reviewer:	

Example No. 3 – Level 1 Assessment

UTILITY PROFILE
Eagle Cliff is a community water system that receives its water from a spring source and serves 5,500 people. It collects 6 routine samples per month.

DESCRIPTION OF THE PROBLEM
In July 2009, the routine sample and one of its associated repeat samples both came back total coliform-positive triggering a Level 1 assessment.

ASSESSMENT AND CORRECTIVE ACTION
Upon inspection of the distribution system piping, small factures were found in the water main leading from the spring source to a water tank. The piping was replaced and additional samples were taken to determine whether coliforms were still present in the system. The results came back negative.

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CONCEPT EXAMPLE NO. 3
Level 1 Assessment Form

System Name: **Eagle Cliff**	Source Water: **Spring**	PWSID # **3456712**
System Type: **CWS**	Population Served: **5,500**	PWS Address:
Operator in Responsible Charge (ORC): **F. Langdon**	Phone: **012-345-6789**	**456 Anyway St., Eagle Cliff, AL 10000**
City, State: **Eagle Cliff, AL**		
County: **Hoover**		
Person that collected TC samples if different than ORC: **C. Heart**	Phone: **123-456-7890**	
Address, City, State, Zip: **333 Third St., Eagle Cliff, AL 10000**		
Date Assessment Completed: **9/1/2009**		

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples? -any interruptions in the treatment process -any reported loss of pressure events (5 psi) -operation and maintenance activities that could have introduced total coliform -reported vandalism and/or unauthorized access to facilities -visible indicators of unsanitary conditions reported -Has there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**No**		
2. Have there been any recent operational changes to the system? -sources introduced -treatment or operational changes -potential sources of contamination	✓	**No**		
3. Evaluate sample site. -condition or location of tap -regular use of connection	✓	**No**		
4. Sample protocol followed and reviewed. -flush tap -remove aerator -no swivel -fresh sample bottles -sample storage acceptable	✓	**No**		
5. Distribution System -system pressure -cross connection -pump station -air relief valves -fire hydrants or blow off -breaks -repairs	✓	**Yes**	Small fractures detected in raw water line from spring to tank.	Raw water line replacement completed on 8/30/2009

CONCEPT EXAMPLE NO. 3
Level 1 Assessment Form

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
6. Storage Tank -screens -security -access opening -condition of tank -vent -drain overflow -pressure tank -O&M	✓	**No**		
7. Treatment Process -interruptions -POE/POU -softeners -O&M	✓	**No**		
8. Source - Well -sanitary seal -vent screened -air gap -cross connection -security -pump to waste line	**N/A**			
9. Source - Spring -condition of spring development -condition of spring box -security	✓	**No**		
10. Source - Surface Water Supply -heavy rainfall -rapid snowmelt	**N/A**			

Note: Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

Print name of person completing form: **Michael Taylor** Date: **09-01-2009**
Signature: _____

Reserved for State

1.	Assessment has been successfully completed.	
2.	Likely reason for total coliform-positive occurrence is established.	
3.	System has corrected the problem.	
4.	Was a reset requested and / or granted? – Rationale	
5.	Name of State reviewer:	

Example No. 4 – Level 1 Assessment

UTILITY PROFILE

Eggleston Glen is a large municipal water system that is supplied by a ground water source under the direct influence of surface water (GWUDI). The system treats its water before serving it to its 985,000 customers. It collects over 300 routine samples per month.

DESCRIPTION OF THE PROBLEM

In August 2009, more than 5% of the monthly total coliform samples came back positive triggering a Level 1 assessment. Many of the positive samples were in the same general location in the distribution system and in proximity to a large ground storage tank. Several days prior to the collection of the positive samples, the system experienced pressure loss for a period of 4 hours while the media in the GAC filters at one of the plants was being changed out. During this time the tank levels dropped to near empty.

ASSESSMENT AND CORRECTIVE ACTION

Normally stagnant water from the tank entered the distribution system during the pressure loss event causing the total coliform positive results. The tank was taken off-line, cleaned and shock chlorinated in accordance with State guidelines before putting it back on service. The distribution system near the tank was also flushed to improve water turnover.

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CONCEPT EXAMPLE NO. 4
Level 1 Assessment Form

System Name: **Eggleston Glen**	Source Water: **GWUDI**	PWSID # **4567123**
System Type: **CWS**	Population Served: **985,000**	PWS Address:
Operator in Responsible Charge (ORC): **J. Griffin**	Phone: **012-345-6789**	**123 Anyway St., Eggleston Glen, CO 10000**
City, State: **Eggleston Glen, CO**		
County: **Hoover**		
Person that collected TC samples if different than ORC: **V. Lewis, GHG Labs**	Phone: **123-456-7890**	
Address, City, State, Zip: **444 Fourth St., Littletown, CO 20000**		
Date Assessment Completed: **8/28/2009**		

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples? -any interruptions in the treatment process -any reported loss of pressure events (5 psi) -operation and maintenance activities that could have introduced total coliform -reported vandalism and/or unauthorized access to facilities -visible indicators of unsanitary conditions reported -Has there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**Yes**	Loss of system pressure for 4 hours while changing media in GAC filters. Tank level dropped to near empty. This may have allowed "old" water to enter the system from system tank.	Distribution system flushed on 8/15/2009, especially near the tank to improve turnover. Tank was taken off-line, cleaned, and shock chlorinated in accordance with State guidelines before putting it back on service. Chlorine will be checked at sample location at least two times per month.
2. Have there been any recent operational changes to the system? -sources introduced -treatment or operational changes -potential sources of contamination	✓	**No**		
3. Evaluate sample site. -condition or location of tap -regular use of connection	✓	**No**		
4. Sample protocol followed and reviewed. -flush tap -remove aerator -no swivel -fresh sample bottles -sample storage acceptable	✓	**No**		
5. Distribution System -system pressure -cross connection -pump station -air relief valves -fire hydrants or blow off -breaks -repairs	✓	**No**		

CONCEPT EXAMPLE NO. 4
Level 1 Assessment Form

Questions (1-5)	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
6. Storage Tank -screens -security -access opening -condition of tank -vent -drain overflow -pressure tank -O&M	✓	**No**		
7. Treatment Process -interruptions -POE/POU -softeners -O&M	✓	**No**		
8. Source - Well -sanitary seal -vent screened -air gap -cross connection -security -pump to waste line	✓	**Yes**	**See item No. 1**	
9. Source - Spring -condition of spring development -condition of spring box -security	✓	**No**		
10. Source - Surface Water Supply -heavy rainfall -rapid snowmelt	**N/A**			

Note: Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

Print name of person completing form: **John Gilmore** Date: **08-28-2009**
Signature: _____

Reserved for State

1. Assessment has been successfully completed.	
2. Likely reason for total coliform-positive occurrence is established.	
3. System has corrected the problem.	
4. Was a reset requested and / or granted? – Rationale	
5. Name of State reviewer:	

Example No. 5 – Level 2 Assessment

UTILITY PROFILE
Warsaw Falls is a community water system that gets its water from ground water sources. It serves a population of 2,550 people and collects 3 routine samples every month.

DESCRIPTION OF THE PROBLEM
In January 2010, the system had an *E. coli* MCL violation (a routine sample that was *E. coli*-positive followed by a repeat sample that was total coliform-positive) that triggered a Level 2 assessment.

ASSESSMENT AND CORRECTIVE ACTION
The Level 2 assessment revealed unsanitary conditions around one particular well that was located in a parking lot, which may or may not have been the source of the contamination. The system operator noted the need to re-locate or significantly improve the well due to its location and the poor condition of the well casing. The system coordinated with the State to develop interim measures and to work out a schedule to perform the remaining corrective action beyond the 30-day period. The pressure tank was also recently replaced but was not believed to be the source of the contamination as the whole system was shock chlorinated after the tank was replaced.

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CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

System Name: **Warsaw Falls Recreation Center**	Source Water: **Ground Water**	PWSID # **5671234**
System Type: **CWS**	Population Served: **2,550**	PWS Address:
Operator in Responsible Charge (ORC): **Peter Garrison**	Phone: **012-345-6789**	**123 Anyway St., Warsaw Falls, FL 10000**
City, State: **Warsaw Falls, FL**		
County: **Ford**		
Person that collected TC samples if different than ORC: **J. Smith, ABC Labs**	Phone: **123-456-7890**	
Address, City, State, Zip: **012 Main St., Bigtown, FL 11111**		
Date Assessment Completed: **02/10/2010**		

Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples?				
a. Were there any operation and maintenance activities that could have introduced total coliforms?	✓	**No**		
b. Have there been any interruptions in the treatment process?	✓	**No**		
c. Has the system lost pressure to less than 5 psi?	✓	**No**		
d. Have there been any vandalism and/or unauthorized access to facilities?	✓	**No**		
e. Are there any visible indicators of unsanitary conditions observed?	✓	**Yes**	**Unsanitary conditions around well including garbage and parking lot run-off.**	**See item 8.**
f. Have there been any analytical results or any additional samples collected, including source samples which were positive (not for compliance)?	✓	**No**		
g. Have there been any community illness suspected of being waterborne (e.g., Does the community public health official indicate that an outbreak has occurred.)	✓	**No**		
h. Did the water system receive any TCR monitoring violations in the past 12 months? If yes, when.	✓	**No**		
i. What was the most recent date on which satisfactory total coliform samples were taken?	Date: **Dec 2009**			
j. Have there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**No**		
k. Other comments on records and maintenance?	**None**			
2. Have there been any recent treatment or operational changes?				
a. Have any inactive sources recently been introduced into the system (e.g., auxiliary systems)?	✓	**No**		

CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
b. Have there been any new sources introduced into the system?	✓	**No**		
c. Is there evidence of any potential sources of contamination (main breaks, low pressure, high turbidity, loss of disinfection, etc.)?	✓	**No**		
3. Evaluate sample site				
a. What is the condition of the tap? **(Provide comments)**	**Good**			
b. What is the location of the tap? **(Provide comments)**	**Good**			
c. What is the regular use of the connection? **(Provide comments)**	**Raw water tap for sample collection**			
d. Have there been any plumbing changes or construction? If yes, when and what was the repair or change?	✓	**No**		
e. Have there been any plumbing breaks or failure? If yes, when?	✓	**No**		
f. List any identified cross connections after the service connection or in premise plumbing. **(Provide comments)**	**None**			
g. Were all of the backflow prevention devices present, operational and maintained?	✓	**No**		
h. Were there any low pressure events or changes in water pressure after the service connection or in the premise plumbing? If yes, when?	✓	**No**		
i. Is there any treatment devices after the service connection or in premise? **(Circle response, if applicable)**	. Point of Entry (POE) Point of Use (POU)			
j. Other comments on sample site?	**None**			
4. Sample protocol followed and reviewed				
a. Flush tap, remove aerator, no swivel, fresh sample bottles, sample storage acceptable	✓	**No**		
5. Distribution System				
a. System pressure: Is there evidence that the system experienced low or negative pressure? If yes, when?	✓	**No**		
b. List any identified cross connections.	✓	**No**		
c. Pump station: Are there any sanitary defects in the pump station? Are pump(s) operable?	✓	**No**		
d. Last pump maintenance/service date. **(Respond if applicable)**	Date: **12/2006**		Maintenance Performed? **Mechanical seal replaced**	

CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
e.	Air relief valves: Is the valve vault subject to flooding or does the vent terminate below grade?	✓	**No**		
f.	Fire hydrant/blow off: Are any located in an area with a high water table or pits?	✓	**No**		
g.	Is the distribution system secured to prevent unauthorized access?	✓	**No**		
h.	Are the backflow prevention devices at high risk sites present, operational and maintained?	✓	**No**		
i.	Have there been any water main repairs or additions? If yes when, and what was the repair or addition?	✓	**No**		
j.	Have there been any water main breaks? If yes, when?	✓	**No**		
k.	Was there any scheduled flushing of the distribution system? If yes, when?	✓	**No**		
l.	Is there any evidence of intentional contamination in the distribution system?	✓	**No**		
m.	Other comments on the distribution information.	**None**			
6. Storage Facilities					
a.	Are the overflow and vents properly screened?	✓	**No**		
b.	Is the facility secured to prevent unauthorized access?	✓	**No**		
c.	Does the access opening have the proper gasket and seal tightly?	✓	**No**		
d.	Could the physical condition of tank be a source of contamination?	✓	**No**	**The pressure tank was recently replaced.**	**Whole system was shock chlorinated after the tank replacement. It is not believed there is correlation between the bacteria found and the work on this tank.**
e.	Is the vent turned down and maintaining an approved air gap at the termination point?	✓	**No**		
f.	Does the drain/overflow line terminate at a minimum of 12" air gap?	✓	**No**		
g.	If present, is the pressure tank maintaining an appropriate minimum pressure?	✓	**No**		
h.	Has proper O&M been performed?	✓	**No**		
i.	Was there any observed physical deterioration of the tank?	✓	**No**		
j.	Were there any observed leaks?	✓	**No**		
k.	Is there any evidence of intentional contamination at the storage tank?	✓	**No**		
l.	Has there been any facility maintenance (i.e. painting/coating)? If yes, when?	✓	**No**		

CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
m.	Is facility maintenance occurring per appropriate schedule?	✓	**No**		
n.	Does the tank "float" on the distribution system or are there separate inlet and outlet lines?	✓	**No**		
o.	What is the measured chlorine residual (total/free) of the water exiting the storage tank today?	Residual **N/A**			
p.	Are there any unsealed openings in the storage facility such as access doors, vents or joints?	✓	**No**		
q.	Other comments on the storage system	**None**			
7. Treatment Process. (If applicable)					
a.	Treatment devices operational and maintained?	**N/A**			
b.	Is there any recent installation or repair of treatment equipment?	**N/A**			
c.	Were there any recent changes in the treatment process? If yes, when, what was the change?	**N/A**			
d.	Were there any interruptions of treatment (lapses in chemical feed, turbidity excursions, disinfection)? If yes which part, when and for how long?	**N/A**			
e.	What is the free chlorine residual measured immediately downstream from the point of application?	**Residual: N/A**			
f.	Did a review of the filter turbidity profiles reveal any anomalies?	**N/A**			
g.	Were there any failures to meet the C x T calculations?	**N/A**			
h.	Were the flow rates above the rated capacity?	**N/A**			
i.	Were there any anomalies on the settled water turbidities?	**N/A**			
j.	Other comments on the treatment system.	**None**			
8. Source – Well					
a.	Is the sanitary seal intact?	✓	**No**		
b.	Is the vent screened?	✓	**No**		
c.	Does the vent and pump to waste terminate in an approved air gap?	✓	**No**		
d.	Are there any unprotected cross connections at the wellhead?	✓	**No**		
e.	How is the well used? **(Circle if applicable)**	(Primary) Backup Emergency Not a PWS Not Drinking Water			

CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
f.	How far does the casing extend above grade?	Height **14 inches**		Comments:	
g.	Is the well cap vented?	✓	**No**		
h.	Is there evidence of standing water near the wellhead?	✓	**Yes**	**After heavy rain events, there is standing water for a day or two.**	
i.	Is the wellhead secured to prevent unauthorized access?	✓	**No**		
j.	Have there been any sewer spills, source water spills or other disturbances?	✓	**No**		
k.	Other comments on the well system. (Are there aspects of well construction and operation that would bear on observed positives?)	**Well needs significant rehabilitation or relocation, requiring more than 30 days. Coordinated with district engineer to develop schedule and interim measures. Well will be kept off-line to greatest extent possible, with the State to be notified and chlorine disinfection to be applied at 2 mg/L whenever well is put on-line. Engineering feasibility study and corrective action recommendation and proposed completion schedule due to State by 3/10/10. Corrective action and completion schedule approved by State by 3/25/10.**			
9. Source – Spring					
a.	What is the condition of the spring development?	**N/A**			
b.	What is the condition of the spring box?	**N/A**			
c.	Is the spring secured to prevent unauthorized access?	**N/A**			
d.	Other comments on the spring system.	**None**			
10. Source - Surface Water Supply					
a.	Have there been any sewer spills, source water spills or other disturbances?	**N/A**			
b.	Have there been any algal blooms?	**N/A**			
c.	Has source water turnover occurred?	**N/A**			
d.	Other source water comments	**None**			
Environmental Events					
a.	Has there been heavy rainfall?	✓	**Yes**	**See Item 8.**	
b.	Has there been any rapid snow melt or flooding?	✓	**No**		
c.	Have there been changes in available source water (e.g., significant drop in water table, well levels, reservoir capacity, etc.)	✓	**No**		
d.	Have there been any interruptions to electrical power?	✓	**No**		
e.	Have there been any extremes in heat or cold?	✓	**No**		

Note : Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

CONCEPT EXAMPLE NO. 5
Level 2 Assessment Form

Additional Comments:

Print name of person completing form: **Chris Weaver** Date: **02/03/2010**
Signature: _____

Reserved for State

1. Assessment has been successfully completed. ☐ Name of State Reviewer: _____

Example No. 6 – Level 2 Assessment

UTILITY PROFILE
Chimney Bluffs Community Church is a transient non-community water system that gets its water from a ground water source. It serves a population of about 200 people and takes a routine sample every quarter.

DESCRIPTION OF THE PROBLEM
The system had two total coliform-positive samples in July 2009 and again in March 2010 triggering a Level 2 assessment (2 Level 1 assessments within a rolling 12-month period). Since the system does not have anyone approved by the State to perform a Level 2 assessment, the Operator in Responsible Charge (ORC) identified an assessor approved by the State from the State website.

ASSESSMENT AND CORRECTIVE ACTION
The system noted three possible sources of contamination: 1) inadequate/improper chlorination of an in-line conditioner after replacement of pressure tank and plumbing; 2) need for replacement of filters in the reverse osmosis system; and 3) use of a swivel faucet at the sampling site. The system suspected the first possible source as the cause of the contamination and chlorinated the in-line conditioner in March 2010. The old swivel faucet was also replaced.

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CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

System Name: **Chimney Bluffs Community Church**	Source Water: **Ground Water**	PWSID # **6712345**
System Type: **TNCWS**	Population Served: **200**	PWS Address: **123 Anyway St., Chimney Bluffs, AZ 10000**
Operator in Responsible Charge (ORC): **Mary Spelling**	Phone: **012-345-6789**	
City, State: **Chimney Bluffs, AZ**		
County: **Jackson**		
Person that collected TC samples if different than ORC: **A. Brown, ABC Labs**	Phone: **123-456-7890**	
Address, City, State, Zip: **7556 Desert Ave, Tempe, AZ 99999**		
Date Assessment Completed: **04/06/2010**		

Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
1. Have any of the following occurred at relevant facilities prior to the collection of TC samples?				
a. Were there any operation and maintenance activities that could have introduced total coliforms?	✓	**Yes**	**The pressure tank and plumbing in and around the pump room were recently replaced. System includes an in-line water conditioner. It is unknown if water conditioner was chlorinated or by-passed during the chlorination prior to putting tank and plumbing back in service.**	**Water conditioner chlorinated on 3/30/2010 and put back in service.**
b. Have there been any interruptions in the treatment process?	✓	**No**		
c. Has the system lost pressure to less than 5 psi?	✓	**No**		
d. Have there been any vandalism and/or unauthorized access to facilities?	✓	**No**		
e. Are there any visible indicators of unsanitary conditions observed?	✓	**No**		
f. Have there been any analytical results or any additional samples collected, including source samples which were positive (not for compliance)?	✓	**No**		
g. Have there been any community illness suspected of being waterborne (e.g., Does the community public health official indicate that an outbreak has occurred.)	✓	**No**		
h. Did the water system receive any TCR monitoring violations in the past 12 months? If yes, when.	✓	**Yes**	**July 2009**	
i. What was the most recent date on which satisfactory total coliform samples were taken?	Date: **Dec 2009**			
j. Have there been a fire fighting event, flushing operation, sheared hydrant, etc.	✓	**No**		
k. Other comments on records and maintenance?	**None**			
2. Have there been any recent treatment or operational changes?				

CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
a.	Have any inactive sources recently been introduced into the system (e.g., auxiliary systems)?	✓	**No**		
b.	Have there been any new sources introduced into the system?	✓	**No**		
c.	Is there evidence of any potential sources of contamination (main breaks, low pressure, high turbidity, loss of disinfection, etc.)?	✓	**No**		
3.	**Evaluate sample site**				
a.	What is the condition of the tap? **(Provide comments)**	**Fair**			
b.	What is the location of the tap? **(Provide comments)**	**church rectory**			
c.	What is the regular use of the connection? **(Provide comments)**	**potable water source for the rectory**			
d.	Have there been any plumbing changes or construction? If yes, when and what was the repair or change?	✓	**No**		
e.	Have there been any plumbing breaks or failure? If yes, when?	✓	**No**		
f.	List any identified cross connections after the service connection or in premise plumbing. **(Provide comments)**	**In-line water conditioner**			
g.	Were all of the backflow prevention devices present, operational and maintained?	✓	**No**		
h.	Were there any low pressure events or changes in water pressure after the service connection or in the premise plumbing? If yes, when?	✓	**No**		
i.	Is there any treatment devices after the service connection or in premise? **(Circle response, if applicable)**	(Point of Entry (POE))	Point of Use (POU)		
j.	Other comments on sample site?	**None**			
4.	**Sample protocol followed and reviewed**				
a.	Flush tap, remove aerator, no swivel, fresh sample bottles, sample storage acceptable	✓	**Yes**	**Sample site had old swivel faucet.**	**Faucet replaced on 3/30/10.**
5.	**Distribution System**				
a.	System pressure: Is there evidence that the system experienced low or negative pressure? If yes, when?	✓	**No**		
b.	List any identified cross connections.	✓	**No**		
c.	Pump station: Are there any sanitary defects in the pump station? Are pump(s) operable?	✓	**No**		
d.	Last pump maintenance/service date. **(Respond if applicable)**	Date: **N/A**		Maintenance Performed?	

CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
e.	Air relief valves: Is the valve vault subject to flooding or does the vent terminate below grade?	✓	**No**		
f.	Fire hydrant/blow off: Are any located in an area with a high water table or pits?	✓	**No**		
g.	Is the distribution system secured to prevent unauthorized access?	✓	**No**		
h.	Are the backflow prevention devices at high risk sites present, operational and maintained?	✓	**No**		
i.	Have there been any water main repairs or additions? If yes when, and what was the repair or addition?	✓	**No**		
j.	Have there been any water main breaks? If yes, when?	✓	**No**		
k.	Was there any scheduled flushing of the distribution system? If yes, when?	✓	**No**		
l.	Is there any evidence of intentional contamination in the distribution system?	✓	**No**		
m.	Other comments on the distribution information.	**None**			
6. Storage Facilities					
a.	Are the overflow and vents properly screened?	**N/A**			
b.	Is the facility secured to prevent unauthorized access?	**N/A**			
c.	Does the access opening have the proper gasket and seal tightly?	**N/A**			
d.	Could the physical condition of tank be a source of contamination?	**N/A**			
e.	Is the vent turned down and maintaining an approved air gap at the termination point?	**N/A**			
f.	Does the drain/overflow line terminate at a minimum of 12" air gap?	**N/A**			
g.	If present, is the pressure tank maintaining an appropriate minimum pressure?	**N/A**			
h.	Has proper O&M been performed?	**N/A**			
i.	Was there any observed physical deterioration of the tank?	**N/A**			
j.	Were there any observed leaks?	**N/A**			
k.	Is there any evidence of intentional contamination at the storage tank?	**N/A**			
l.	Has there been any facility maintenance (i.e. painting/coating)? If yes, when?	**N/A**			
m.	Is facility maintenance occurring per appropriate schedule?	**N/A**			

CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
n.	Does the tank "float" on the distribution system or are there separate inlet and outlet lines?	**N/A**			
o.	What is the measured chlorine residual (total/free) of the water exiting the storage tank today?	Residual **N/A**			
p.	Are there any unsealed openings in the storage facility such as access doors, vents or joints?	**N/A**			
q.	Other comments on the storage system	**None**			
7. Treatment Process. (If applicable)					
a.	Treatment devices operational and maintained?	✓	**No**		
b.	Is there any recent installation or repair of treatment equipment?	✓	**Yes**	**The filters were replaced in the reverse osmosis system that feeds the faucets connected to the rectory and the kitchen.**	**Filter replacement has never been the source of contamination in the past and is not believe to be related to this event.**
c.	Were there any recent changes in the treatment process? If yes, when, what was the change?	✓	**No**		
d.	Were there any interruptions of treatment (lapses in chemical feed, turbidity excursions, disinfection)? If yes which part, when and for how long?	✓	**No**		
e.	What is the free chlorine residual measured immediately downstream from the point of application?	**Residual: N/A**			
f.	Did a review of the filter turbidity profiles reveal any anomalies?	**N/A**			
g.	Were there any failures to meet the C x T calculations?	**N/A**			
h.	Were the flow rates above the rated capacity?	**N/A**			
i.	Were there any anomalies on the settled water turbidities?	**N/A**			
j.	Other comments on the treatment system.	**None**			
8. Source – Well					
a.	Is the sanitary seal intact?	✓	**No**		
b.	Is the vent screened?	✓	**No**		
c.	Does the vent and pump to waste terminate in an approved air gap?	✓	**No**		
d.	Are there any unprotected cross connections at the wellhead?	✓	**No**		
e.	How is the well used? **(Circle if applicable)**	(Primary) Backup	Emergency	Not a PWS	Not Drinking Water
f.	How far does the casing extend above grade?	Height _____	Comments:		

CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

	Questions	Reviewed and checked? (Type "✓" if completed or "N/A")	Issue(s) found? (Y/N)	Issue Description	Corrective Action Taken (Including Date)
g.	Is the well cap vented?	✓	**No**		
h.	Is there evidence of standing water near the wellhead?	✓	**No**		
i.	Is the wellhead secured to prevent unauthorized access?	✓	**No**		
j.	Have there been any sewer spills, source water spills or other disturbances?	✓	**No**		
k.	Other comments on the well system. (Are there aspects of well construction and operation that would bear on observed positives?)	**None**			
9. Source – Spring					
a.	What is the condition of the spring development?	**N/A**			
b.	What is the condition of the spring box?	**N/A**			
c.	Is the spring secured to prevent unauthorized access?	**N/A**			
d.	Other comments on the spring system.	**None**			
10. Source - Surface Water Supply					
a.	Have there been any sewer spills, source water spills or other disturbances?	**N/A**			
b.	Have there been any algal blooms?	**N/A**			
c.	Has source water turnover occurred?	**N/A**			
d.	Other source water comments	**None**			
Environmental Events					
a.	Has there been heavy rainfall?	✓	**No**		
b.	Has there been any rapid snow melt or flooding?	✓	**No**		
c.	Have there been changes in available source water (e.g., significant drop in water table, well levels, reservoir capacity, etc.)	✓	**No**		
d.	Have there been any interruptions to electrical power?	✓	**No**		
e.	Have there been any extremes in heat or cold?	✓	**No**		

Note : Form to be completed based on data and documents available to the PWS operator in charge, maintained on file and returned to the Primacy Agency within XX days.

Additional Comments:

CONCEPT EXAMPLE NO. 6
Level 2 Assessment Form

Print name of person completing form: **John Marshall** Date: **04/08/2010**
Signature: _____

Reserved for State		
1. Assessment has been successfully completed.	☐	Name of State Reviewer: _____

Appendix C

Common Sanitary Defects and Corrective Actions

Appendix C presents a summary of the causes of total coliform- / *E. coli*-positive (TC+/EC+) results that have been frequently found in the past and the corresponding corrective action(s) that systems can take to correct the problem. It is intended to give concise guidance in a look-up table format that PWSs can easily refer to in the event that they are triggered to have an assessment and perform corrective action. Some of the materials in the following table are discussed in more detail in Chapter 4 of this document.

The list is by no means comprehensive or exhaustive and does not include investigation, operation and maintenance, or corrective action guidance particular to each State. Systems should be aware of State guidelines and consult with the State as necessary.

The list of sanitary defects is based on the common causes of TC+/EC+ reported by States and PWSs. **EPA is interested in hearing from the public on other possible causes of TC+ and EC+ they want to see address in this guidance manual.**

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Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
Biofilms	• Taste and odor complaints • Colored or turbid water that takes a long time to clear • Elevated heterotrophic plate count (HPC) bacteria levels • Numerous isolates with similar genotypic profile	• Conduct unidirectional flushing to remove biofilm and sediments from distribution system. • Maintain adequate pressure in system to prevent sloughing of biofilm by installing booster pump stations, variable frequency drives, elevated storage facilities, surge relief valves, and surge tanks, and modifying high service pumps. Install automatic pressure monitoring and control. • Replace/rehabilitate pipe where biofilm sloughing is occurring. • Maintain disinfectant residuals in the distribution system. • Apply temporary disinfection, shock chlorination, and/or booster disinfection, in accordance with State guidelines. • Manage water age by looping dead ends; increasing volume turnover; and/or installing appropriate main sizes, automated flushing devices, or mixing devices.	• Water Research Foundation, *Strategies for Managing Total Coliform and E. Coli in Distribution Systems*, 2009. • Water Research Foundation, *Factors Limiting Microbial Growth in Distribution Systems: Laboratory and Pilot Scale Experiments*, 1996. • Water Research Foundation, *Assessing and Controlling Regrowth in Distribution Systems*, 1990. • Water Research Foundation, *Factors Affecting Microbial Growth in Model Distribution Systems*, 2000. • Camper, A. K. *et al*., "Effect of Distribution System Materials on Bacterial Regrowth." Journal AWWA , Vol. 95 Iss. 7, July 2003, Page(s) 107-121.
Contamination of water during main installation, repair, or rehabilitation	• Break/repair activities that could have allowed entry of contaminants or dislodged accumulated pipe debris into bulk water • Pressure loss associated with break	• Flush system (spot or routine). • Apply temporary disinfection, shock chlorination, and/or booster disinfection in accordance with State guidelines.	• AWWA C651 (Standard for Disinfecting Water Mains)

Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
	• Low disinfectant residual • Colored or turbid water	• Review/enhance existing procedures for main installation, repair, or rehabilitation procedures. • Maintain adequate pressure in the system by installing booster pump stations, variable frequency drives, elevated storage facilities, surge relief valves, and surge tanks, and modifying high service pumps. Install automatic pressure monitoring and control.	
Cross-connections	• Pressure loss event within a portion of the distribution system • Total coliform-positive samples occur at high elevation and/or low pressure location(s) • Presence of a high-risk customer for backflow (e.g., industrial user)	• Eliminate cross-connection. • Implement cross-connection control and backflow prevention (CCBFP) program. • Install backflow prevention assemblies and devices. • Flush system (spot or routine). • Apply temporary disinfection, shock chlorination, and/or booster disinfection in accordance with State guidelines. • Maintain adequate pressure in system to prevent backflow and backsiphonage by installing booster pump stations, variable frequency drives, elevated storage facilities, surge relief valves, and surge tanks, and modifying high service pumps. Install automatic pressure monitoring and control.	• Cross-Connection Control Manual, EPA 816-R-03-002, EPA, February 2003
Errors in the sampling protocol (i.e., proper	• Changes in sampler or protocol	• Review current protocol and if inadequate, identify alternate	• Water Research Foundation, *Sample*

Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
sampling protocols were not followed – e.g., tap was not flushed, aerator was not removed, etc.)		protocol. • Enhance training on site preparation, flushing protocols, and sanitary sample collection and transport procedures. • Sanitize sample coolers and ice packs. Ensure that samples are shipped properly and securely (e.g., bottles do not tip or become contaminated during transport).	*Collection Procedures and Locations for Bacterial Compliance Monitoring*, 2004 • Interactive Sampling Guide for Drinking Water System Operators CD, available at: *http://www.epa.gov/ncepihom/*
Inadequacies of the sample site (e.g., unsanitary conditions, leaks and breaches, unprotected access, improper construction, improper location)	• Changes in sampling site use • Presence of unsanitary conditions at the sampling site	• Develop a sample siting plan that is representative of the water quality in the distribution system. • Install dedicated sampling taps. • Correct leaks or other site deficiencies and breaches. • Sanitize or replace sampling site.	• Water Research Foundation, *Sample Collection Procedures and Locations for Bacterial Compliance Monitoring*, 2004 • Interactive Sampling Guide for Drinking Water System Operators CD, available at: *http://www.epa.gov/ncepihom/*
Inadequate disinfectant residual levels in the distribution system	• Variable raw and/or treated water quality conditions • Inadequate disinfectant at entry point • Inadequate disinfectant at booster stations • Interruptions in disinfection processes • Increases in temperature that lead to accelerated disinfectant decay	• Apply temporary disinfection, shock chlorination, and/or booster disinfection in accordance with State guidelines. • Manage water age by looping dead ends; increasing volume turnover; and/or installing appropriate main sizes, automated flushing devices, or mixing devices. • Install/upgrade on-line water	• AWWA G200 (Standard for Distribution Systems Operation and Management)

Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
		quality monitoring and control. • Flush system (spot or routine).	
Intrusion through pipe leaks, pipeline fracture cracks, leaking joints, submerged air-vacuum/ air-release valves, and deteriorating seals	• Pressure loss or reduction in a portion of the distribution system • Presence of leaks, cracks and other entry points • High groundwater table and/or presence of sewers near the susceptible water main • Numerous isolates with unique genotypic profile	• Repair/replace leaky component. • Maintain adequate pressure in system by installing booster pump stations, variable frequency drives, elevated storage facilities, surge relief valves, and surge tanks, and modifying high service pumps. Install automatic pressure monitoring and control.	• Water Research Foundation, *Verification and Control of Pressure Transients and Intrusion in Distribution Systems*, 2004.
Pressure loss (can result from events such as flushing, main breaks, power outages, fires, or improper operations and management (O&M) practices)	• Recent maintenance activities, main breaks, power outages, fires • Turbidity increase or fluctuations	• Flush distribution system (spot or routine). • Apply temporary disinfection, shock chlorination, and/or booster disinfection in accordance with State guidelines. • Improve O&M practices. • Maintain adequate pressure by installing booster pump stations, variable frequency drives, elevated storage facilities, surge relief valves, and surge tanks, and modifying high service pumps. • Install automatic pressure monitoring and control.	• AWWA C651 (Standard for Disinfecting Water Mains) • AWWA G200 (Standard for Distribution Systems Operation and Management)
Sediment build-up in storage tank or reservoir	• Increased disinfectant demands • Increase in turbidity, particularly in water samples collected when tank is draining • Elevated HPC in samples from tank or reservoir • Low disinfectant residual in	• Drain and flush tank or reservoir. • Shock chlorination of tank or reservoir in accordance with State guidelines.	• AWWA C652 (Disinfection of Water-Storage Facilities)

Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
	samples from tank or reservoir		
Storage tank physical deficiencies like holes, inadequate screening, etc. (can allow entry of birds, animals, insects, and other vectors that can fecally contaminate the water)	• Presence of physical deficiencies • Recent work on or near the tank • Recent vandalism, storm events, or other events that could impact tank integrity	• Repair broken parts of storage tank like the vent and hatch. • Repair / install screens. • Install / improve security measures.	• AWWA C652 (Disinfection of Water-Storage Facilities)
Contamination during flushing/firefighting activities	• Turbidity increase or fluctuations • Color increase or fluctuations • Pressure fluctuations	• Ensure unidirectional flushing approach is used for flushing program and that water quality objectives (i.e., chlorine, turbidity, and iron) are met prior to terminating flushing.	• Water Research Foundation, *Implementation and Optimization of Distribution Flushing Programs*, 1992 • Water Research Foundation, *Deterioration of Water Quality in Distribution Systems*, 1987 • Water Research Foundation, *Development of Distribution System Water Quality Optimization Plans,* 2005
Treatment breakthrough	• Variable raw and/or treated water quality conditions • Inadequate disinfectant at entry point • Elevated HPC bacteria levels occur throughout the distribution system	• Increase disinfectant residual. Apply temporary disinfection, shock chlorination, and/or booster disinfection in accordance with State guidelines. • Flush system (spot or routine). • Assess performance of treatment processes and remedy cause of coliform breakthrough (e.g.,	• Small Systems Guide to Safe Drinking Water Act Regulations, EPA 2003: *http://www.epa.gov/safewater/*

Sanitary Defects / Cause(s) of TC+ and EC+	Conditions That May Point to Cause of TC+/EC+	Possible Corrective Action(s)	For Additional Information
		replace filter, decrease particle loading, etc.).	
Vandalism and/or unauthorized access to facilities	• Recent work or other events at a distribution system facility • Presence of broken or disabled security equipment	• Flush system (spot or routine). • Install / improve security measures (e.g., install a fence, lock buildings, install alarms and cameras) • Develop and implement an operations plan. • Develop standard operating procedures (SOPs). • Develop emergency response plan.	• AWWA G200 (Standard for Distribution Systems Operation and Management) • Water Research Foundation, *Distribution System Security Primer for Water Utilities*, 2005.

Appendix D

Industry Standards for Operating a Public Water System

The American Water Works Association (AWWA) has developed standards based on the collective knowledge of its membership. The information contained in these standards has been collected and improved over many years and has gone through rigorous review and development. AWWA Standards are typically minimum best practices and help to ensure that a product (e.g., pipes, fittings, meters, etc.) or a process (e.g., main flushing, main installation, etc.) described in a standard will provide satisfactory service.

Although not a complete list, the following AWWA Standards may be useful as a reference when implementing the corrective action(s) discussed in the RTCR Assessments and Corrective Actions Guidance Manual and its appendices.

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Standard Number	Topic
AWWA A100	Water Wells
AWWA B300	Hypochlorites
AWWA B301	Liquid Chlorine
AWWA C104/A21.4	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C116/A21.16	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service
AWWA C150/A21.50	Thickness Design of Ductile-Iron Pipe-Erratum: 02/2003
AWWA C151/A21.51	Ductile-Iron Pipe, Centrifugally Cast, for Water- Erratum
AWWA C153/A21.53	Ductile-Iron Compact Fittings, for Water Service
AWWA C200	Steel Water Pipe - 6 in. (150 mm) and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm)
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C213	Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C215	Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines
AWWA C216	Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C217	Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines
AWWA C218	Coating the Exterior of Aboveground Steel Water Pipelines and Fittings-Third Edition
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings-First Edition
AWWA C224	Two-Layer Nylon-11-Based Polyamide Coating System for the Interior and Exterior of Steel Water Pipe, Connecctions, Fittings, and Special Sections

Standard Number	Topic
AWWA C225	Fused Polyolefin Coating systems for the Exterior of Steel Water Pipelines-First Edition
AWWA C300	Reinforced Concrete Pressure Pipe, Steel-Cylinder Type
AWWA C301	Prestressed Concrete Pressure Pipe, Steel-Cylinder Type-Erratum - January 2000
AWWA C302	Reinforced Concrete Pressure Pipe, Noncylinder Type
AWWA C303	Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
AWWA C304	Design of Prestressed Concrete Cylinder Pipe
AWWA C400	Asbestos-Cement Pressure Pipe, 4 in. Through 16 in. (100 mm Through 400 mm), for Water Distribution Systems
AWWA C401	The Selection of Asbestos-Cement Pressure Pipe, 4 in. Through 16 in.(100 mm Through 400 mm), for Water Distribution Systems
AWWA C402	Asbestos-Cement Transmission Pipe, 18 in. Through 42 in. (450 mm Through 1,050 mm), for Water Supply Service
AWWA C403	Selection of Asbestos-Cement Transmission Pipe, Sizes 18 in. Through 42 in. (450 mm Through 1,050 mm), for Water Supply Service
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C502	Dry-Barrel Fire Hydrants
AWWA C503	Wet-Barrel Fire Hydrants
AWWA C508	Swing-Check Valves for Waterworks Service, 2-in. Through 24-in. (50-mm Through 600-mm) NPS
AWWA C509	Resilient-Seated Gate Valves for Water Supply Service
AWWA C512	Air Release, Air/ Vacuum, and Combination Air Valves for Waterworks Service
AWWA C515	Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service-Second Edition
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C602	Cement-Mortar Lining of Water Pipelines in Place - 4 in. (100 mm) and Larger
AWWA C605	Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water-First Edition
AWWA C606	Grooved and Shouldered Joints
AWWA C651	Disinfecting Water Mains
AWWA C652	Disinfection of Water-Storage Facilities
AWWA C653	Disinfection of Water Treatment Plants
AWWA C654	Disinfection of Wells
AWWA C700	Cold-Water Meters - Displacement Type, Bronze Main Case
AWWA C701	Cold-Water Meters - Turbine Type, for Customer Service
AWWA C702	Cold-Water Meters - Compound Type
AWWA C703	Cold-Water Meters - Fire Service Type
AWWA C704	Propeller-Type Meters for Waterworks Applications

Standard Number	Topic
AWWA C706	Direct-Reading, Remote-Registration Systems for Cold-Water Meters
AWWA C707	Encoder-Type Remote-Registration Systems for Cold-Water Meters
AWWA C708	Cold-Water Meters - Multijet Type
AWWA C710	Cold-Water Meters - Displacement Type, Plastic Main Case
AWWA C712	Cold-Water Meters - Singlejet Type-First Edition
AWWA C713	Cold-Water Meters Fluidic-Oscillator Type-First Edition
AWWA C800	Underground Service Line Valves and Fittings
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in.(100 mm Through 300 mm), for Water Distribution
AWWA C901	Polyethylene (PE) Pressure Pipe and Tubing, 1/2 in. (13 mm) Through 3 in. (76 mm), for Water Service
AWWA C903	Polyethylene-Aluminum-Polyethylene & Cross-linked Polyethylene-Aluminum-Cross-linked Polyethylene Composite Pressure Pipes, 1/2 In. (12 mm) Through 2 In. (50 mm), for Water Service
AWWA C905	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 Inches Through 48 Inches (350mm Through 1,200mm), for Water Transmission and Distribution
AWWA C906	Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) Through 63 in. (1,575 mm), for Water Distribution and Transmission
AWWA C907	Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA C909	Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 in. Through 12 in. (100 mm Through 600 mm), for Water Distribution
AWWA C950	Fiberglass Pressure Pipe
AWWA D100	Welded Steel Tanks for Water Storage
AWWA D102	Coating Steel Water-Storage Tanks
AWWA D103	Factory-Coated Bolted Steel Tanks for Water Storage
AWWA D104	Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks
AWWA D110	Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks
AWWA D115	Circular Prestressed Concrete Water Tanks with Circumferential Tendons-First Edition
AWWA D130	Flexible-Membrane Materials for Potable Water Applications
AWWA G100	Water Treatment Plant Operation and Management-First Edition
AWWA G200	Distribution Systems Operation and Management