United States
Environmental Protection
Agency

GROUND WATER RULE
TRIGGERED AND REPRESENTATIVE SOURCE WATER MONITORING GUIDANCE MANUAL

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Although this manual describes suggestions for complying with Ground Water Rule (GWR) requirements, the guidance presented here may not be appropriate for all situations, and alternative approaches may provide satisfactory performance.

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CONTENTS

EXHIBITS

ACRONYMS

AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
ASTM	American Society of Testing Materials
CDC	Centers for Disease Control and Prevention
CCR	Consumer Confidence Report
CFR	*Code of Federal Regulations*
CT	The Residual Concentration of Disinfectant (mg/L) Multiplied by the Contact Time (in minutes)
CWS	Community Water System
DEMs	Digital Elevation Models
DLGs	Digital Line Graphs
DMA	Defense Mapping Agency
EPA	United States Environmental Protection Agency
EROS	Earth Resources Observation Systems
ESICs	Earth Science Information Centers
FR	*Federal Register*
GPS	Global Positioning System
GWR	Ground Water Rule (40 CFR Part 141 Subpart S)
GWS	Ground Water System
GWUDI	Ground Water Under the Direct Influence of Surface Water
HSA	Hydrogeologic Sensitivity Assessment
HPC	Heterotrophic Plate Count
LCR	Lead and Copper Rule (40 CFR Part 141 Subpart I)
NAPP	National Aerial Photography Program
NCGMP	National Cooperative Geologic Mapping Program
NCWS	Non-Community Water System
NRC	National Research Council
NRCS	National Resources Conservation Service
PWS	Public Water System
QA	Quality Assurance
QC	Quality Control
RASA	Regional Aquifer-System Analysis
SDWA	Safe Drinking Water Act
Stage 1 DBPR	Stage 1 Disinfectants and Disinfection Byproducts Rule
Stage 2 DBPR	Stage 2 Disinfectants and Disinfection Byproducts Rule
SWAP	Source Water Assessment Program
TC	Total Coliform
TCR	Total Coliform Rule (40 CFR Part 141 Subpart C)
TDS	Total Dissolved Solids
UCMR	Unregulated Contaminant Monitoring Rule
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	Ultraviolet
WHPAs	Wellhead Protection Areas
WHPP	Wellhead Protection Program

Additional Information

For more information, contact EPA's Safe Drinking Water Hotline at 1-800-426-4791, or see the Office of Ground Water and Drinking Water Web page at http://www.epa.gov/safewater.

This guidance manual is available electronically at:
http://www.epa.gov/safewater/disinfection/gwr/compliancehelp.html.

To order a paper copy of guidance manuals, you may contact the US EPA Water Resource Center at 202-566-1729 or by mail at:

US Environmental Protection Agency
Water Resource Center (RC-4100)
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Guidance Manuals and Materials for the Ground Water Rule

EPA is developing a series of guidance documents to help public water systems implement requirements associated with the Ground Water Rule. Electronic versions of the guidance documents are, or will be, available on the Ground Water Rule Compliance Help page at http://www.epa.gov/safewater/disinfection/gwr/compliancehelp.html.

Complying with the Ground Water Rule: Small Entity Compliance Guide (EPA 815-R-07-018) – This guide is designed for owners and operators of public water systems serving 10,000 or fewer persons that are required to comply with the Ground Water Rule.

Ground Water Rule Corrective Actions Guidance Manual (EPA 815-R-08-011) – This manual provides information for ground water systems that must provide corrective action as a result of significant deficiencies or fecally-contaminated source water. The guidance includes technical information on selecting appropriate disinfection technologies to enable primacy agencies and public water systems to select the treatment most appropriate for a given system. It also provides technical information to States and systems on eliminating sources of contamination, utilizing alternate sources, and correcting significant deficiencies for situations in which disinfection is not the selected corrective action.

Sanitary Survey Guidance Manual for Ground Water Systems (EPA 815-R-08-015) – This guidance provides information to assist States and other primacy programs in conducting sanitary surveys of ground water systems.

Ground Water Rule Source Water Monitoring Methods Guidance Manual (EPA 815-R-07-019) – This manual provides guidance on triggered and optional assessment source water monitoring issues such as: selection of fecal indicators, sample collection and shipping, source water monitoring methods, laboratory quality assurance (QA) and quality control (QC), and evaluation of fecal indicator data. This manual also provides an overview of Ground Water Rule requirements and includes frequently asked questions regarding source water monitoring.

Ground Water Rule Source Assessment Guidance (EPA 815-R-07-023) – This manual provides information on procedures for identifying ground water sources at risk for fecal contamination. Risk factors are discussed with emphasis on identifying readily available factors suitable for desk-top rather than field evaluation of individual public water system wells. The guidance also lists sources of information for making a risk determination, and includes field methods for determining the presence of a hydrogeologic barrier.

Consecutive System Guide for the Ground Water Rule (EPA 815-R-07-020) – This guidance describes the regulatory requirements of the Ground Water Rule that apply to wholesale ground water systems and their consecutive systems.

Other Guidance Manuals and Materials

EPA has developed other guidance manuals to aid EPA, State agencies, and water systems in implementing the Ground Water Rule and other rules, and to help to ensure consistent implementation.

Consider the Source: A Pocket Guide to Protecting Your Drinking Water Pocket Guide #3 (EPA 816-K-02-002) – An electronic version is available at http://www.epa.gov/safewater/sourcewater.

Revised Public Notification Handbook (EPA 816-R-07-003) – An electronic version is available at http://www.epa.gov/safewater/publicnotification/compliancehelp.html.

Preparing Your Drinking Water Consumer Confidence Report (CCR), Revised Guidance for Water Suppliers (EPA 816-R-002) – This document provides information to assist drinking water systems with preparing and distributing Consumer Confidence Reports. An electronic version is available at http://www.epa.gov/safewater/ccr/compliancehelp.html.

Consumer Confidence Report Rule: A Quick Reference Guide (EPA 816-F-02-026) – A condensed guide that provides a brief overview of the Consumer Confidence Report Rule. An electronic version is available at http://www.epa.gov/safewater/ccr/compliancehelp.html.

Surface Water Treatment Rule Guidance Manual – The Appendices include CT tables for the inactivation of *Giardia* and viruses for chlorine, chlorine dioxide and ozone. An electronic version is available at http://www.epa.gov/safewater/mdbp/guidsws.pdf.

1. Introduction

EPA developed the Ground Water Rule (GWR) to provide for increased public health protection for consumers of water from public water systems that use ground water. A key element of the GWR is to identify public ground water sources that are susceptible to fecal contamination. The GWR also ensures that these systems take corrective action to eliminate the source of contamination or to remove or inactivate pathogens in the drinking water they provide to the public. Fecal contamination is a broad term that refers to microbial contaminants from human or animal feces. It is a likely source of microbial pathogens in drinking water. These microbial pathogens are a significant threat to public health because they can cause serious illness and even death when consumed.

Fecal contamination may be introduced into finished ground water via inadequately treated or inadequately protected source water or from problems in the distribution system. Common sources of ground water contamination include septic systems, leaking sewer pipes, landfills, sewage lagoons, and improperly abandoned wells. Microbial contamination in an aquifer can be localized or may be transported as water moves through the aquifer.

The GWR requires ground water systems (GWSs) that provide less than 4-log removal, inactivation, or State-approved combination of these or that do not perform compliance monitoring of treatment to sample their source water for the presence of a fecal indicator when total coliform bacteria are detected in the distribution system. This monitoring requirement is triggered by the results of routine coliform sampling performed for compliance with the Total Coliform Rule (TCR). The triggered monitoring requirement is designed to allow systems and States to identify and to correct public health risks from fecal contamination found at the source. Additionally, assessment source water monitoring may be required for specific systems at the State's discretion. Assessment source water monitoring is routine monitoring of the system's specified ground water source(s) for a fecal indicator at the frequency and duration determined by the State.

If approved by the State, systems with more than one ground water source may conduct triggered source water monitoring at a representative ground water source or sources. The State may require systems with more than one ground water source to submit for approval a triggered source water monitoring plan that the system will use for representative sampling. A triggered source water monitoring plan must identify ground water sources that are representative of each monitoring site in the system's TCR sample siting plan. Systems should consider the relative value of using representative sampling versus the cost of evaluating individual sources and developing a representative monitoring plan. It may be more cost effective for systems, especially small systems, to conduct triggered monitoring when necessary rather than to make an up-front investment in developing a plan. Systems should discuss these options with the State. EPA believes that this alternative can be as protective of public health as monitoring all wellheads, provided that the chosen wells are truly representative of all wellheads. In addition, for situations where a particular sample site is inaccessible, the State may identify an alternate sampling site that is representative of the water quality of the ground water at the inaccessible sample site.

Representative source water monitoring for the GWR, also called representative monitoring, falls within one of two categories:

1. Ground Water Sources Representing Coliform Monitoring Locations in the Distribution System. This relates to situations in which a system has more than one ground water source but not all sources provide water to each total coliform sample collection site in the distribution system. In this case, if approved by the State, only those sources that hydraulically represent (or provide water to) a specific total coliform sample site would need to be sampled under the triggered monitoring provision of the GWR if a routine sample from that site were total coliform-positive.

2. Wells Representative of Other Wells in the same Hydrogeologic Setting. This relates to situations in which a system has multiple sources and some are so similar (e.g., physically and hydrogeologically) that a reasonable case could be made that one source may be representative of another or of others with regard to the risk of fecal contamination. In this case, one or more of the sources would be sampled to indicate the source water quality of all of the representative sources. If approved by the State, representative sources based on physical and hydrogeological properties could be used for triggered monitoring and for assessment source water monitoring.

1.1 Purpose of this Document

The purpose of this guidance manual is to provide GWSs and States with recommendations and examples of the types of information, data, and tools that might be used to demonstrate the appropriateness of representative source water monitoring. Because every system has unique well locations, distribution system hydraulics, and aquifer hydrogeologic characteristics, a decision of whether representative monitoring adequately protects public health should be made on a case-by-case basis by the State or primacy agency.

Although some GWSs may have a wealth of information on which to base representative monitoring requests, many, if not most, GWSs likely have little data but might still be able to make a good case for representative monitoring. This guidance is designed to show the various ways that systems, working with their primacy agency, might use the information at their disposal to demonstrate whether representative monitoring is an appropriate option.

1.2 Relevant Data Considerations for Representative Monitoring Decisions

The type and amount of evidence systems will utilize to make their case for representative monitoring is likely to vary depending on the characteristics of the specific system. For example, a large system with multiple, interconnected pressure zones might utilize a complicated distribution system model to identify sources that are hydraulically representative of each routine total coliform sample site. In contrast, a less complex system might be able to make the same point with a simple map of the distribution system, which includes locations of the system's wells, critical valves, and pressure zones. Similarly, existing information on each well's zone of influence, construction details, source water chemistry, and aquifer characteristics may provide sufficient information to support evaluation of source physical and hydrogeological representativeness.

As discussed in Chapter 4, the suggested steps for identifying representative sources begins by initially grouping those that appear similar to each other using the most readily available information. The grouped wells are then compared using sequentially more complex information. The overall recommended process is one of elimination – removing wells from consideration that would not be representative of other wells with regard to the risk of fecal contamination. It is recommended that water system operators work deliberately through the suggestions addressed in this guidance, gather any information at their disposal, and exercise and document their conclusions based on their best professional judgment.

Ultimately, each State will decide if the specifics of a particular system warrant representative monitoring and should give approval for representative monitoring accordingly. The GWR has granted States flexibility on representative monitoring in that it is not an all-or-nothing approval process. For systems that are interested in sampling at representative well(s), State approval of representative monitoring is required before it can be applied by a system; therefore, a GWS must conduct triggered monitoring at each source prior to State approval. Systems that are interested in sampling at representative source(s) must have prior approval from the State to do so.

1.3 Organization of this Guidance Manual

The remaining six chapters and the two appendices of this guidance manual are organized as follows:

- **Chapter 2 – Ground Water Rule Requirements**: Provides a brief overview of the GWR and how source water monitoring fits into the other regulatory requirements.

- **Chapter 3 – Triggered Monitoring:** Discusses the triggered monitoring provisions of the Ground Water Rule in greater detail.

- **Chapter 4 – Representative Source Water Monitoring**: Provides an overview of the different types of representative monitoring applicable to the GWR. The types include wells representing coliform monitoring locations in the distribution system and wells representative of other wells. This chapter also describes the critical elements of a triggered source water monitoring plan, which some States may require from systems in order to qualify for representative source water monitoring. The chapter also includes a general outline of steps that may be followed to determine whether representative monitoring is appropriate for a GWS. Details of the outlined steps are discussed in subsequent chapters.

- **Chapter 5 – Ground Water Sources Representing Coliform Monitoring Locations in the Distribution System:** Examines what information on distribution system hydraulics may be useful and how it may be applied when considering whether some but not all sources are representative of specific routine total coliform sampling sites.

- **Chapter 6 – Wells Representative of other Wells in the Same Hydrogeologic Setting**: Discusses various source water chemistry, well construction details, and hydrogeological data useful when considering whether a well is representative of the fecal contamination health risk of multiple wells. This chapter is applicable to both triggered source water monitoring and assessment source water monitoring.

- **Chapter 7 – Additional Useful Considerations for Representative Monitoring Proposals**: Examines information systems might consider when finalizing and States might consider when reviewing representative monitoring proposals.

- **Appendix A – Examples of Five Triggered Source Water Monitoring Plans**: Presents five example case studies of hypothetical systems pursuing representative monitoring.

- **Appendix B – Example Triggered Source Water Monitoring Plan (Template)**: Provides a blank template to help water systems develop a Triggered Source Water Monitoring Plan.

- **Appendix C – Summary of Considerations for Representative Monitoring: P**rovides a summary of major points discussed in the *Ground Water Rule Triggered and Representative Source Water Monitoring Guidance Manual*.

2. Ground Water Rule Requirements

EPA published the Ground Water Rule (GWR) in the Federal Register on November 8, 2006 (Federal Register Volume 71, Number 216, 65574) and a rule correction on November 21, 2006 (Federal Register Volume 71, Number 224, 67427). Copies of the Federal Register are available at:

- http://www.epa.gov/fedrgstr/EPA-WATER/2006/November/Day-08/w8763.pdf
- http://www.epa.gov/fedrgstr/EPA-WATER/2006/November/Day-21/w8763.pdf

The GWR addresses source water fecal contamination in systems that use wells or other ground water sources. The rule applies to all public water systems (PWSs) including community and non-community systems regardless of size that:

- Rely entirely on one or more ground water sources;
- Are consecutive systems that receive finished ground water; or
- Mix surface and ground water, where ground water is added directly to the distribution system and provided to consumers without treatment equivalent to the treatment required for surface water.

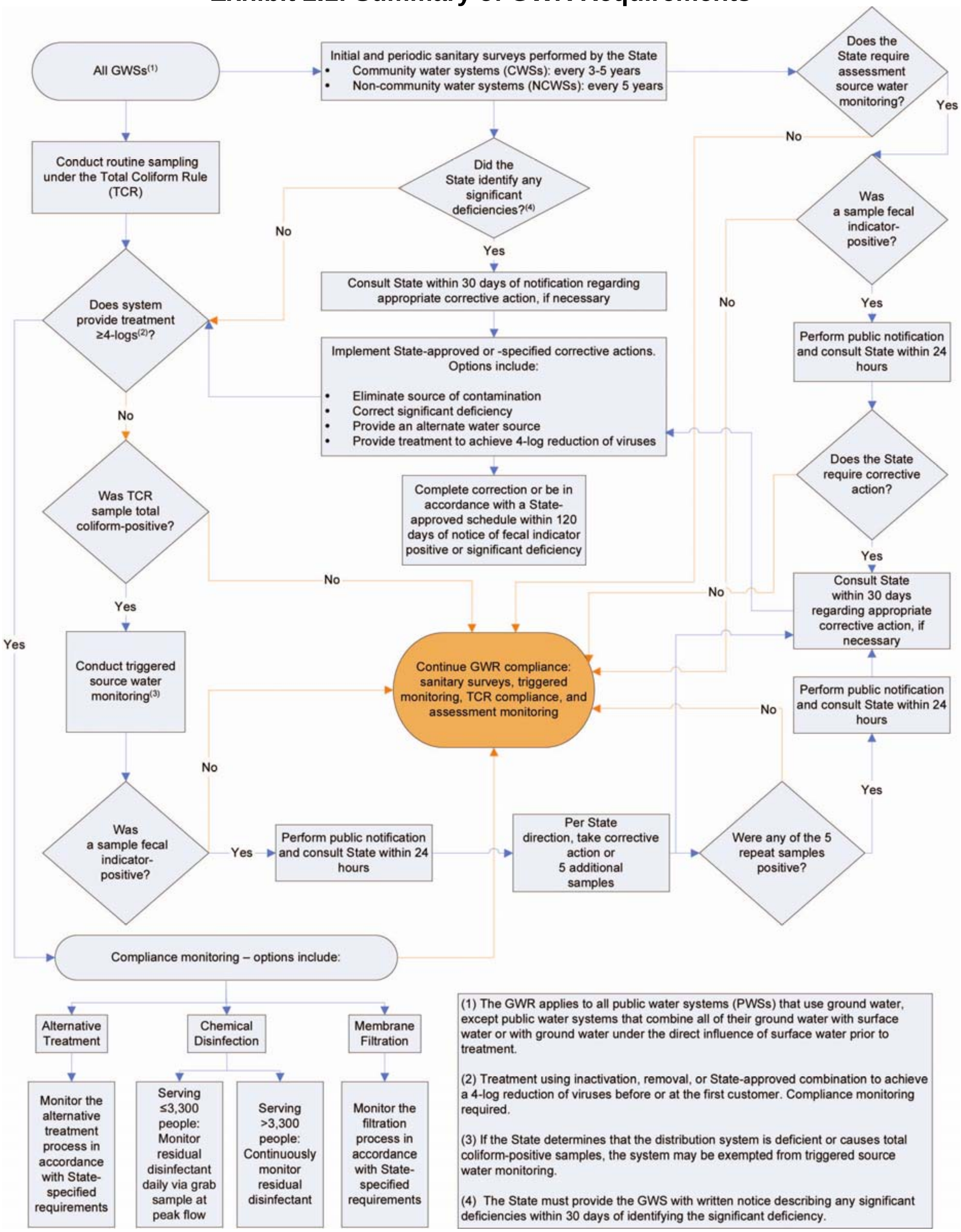
The GWR does not apply to PWSs that combine all of their ground water with surface water before treatment. The GWR also does not apply to systems using ground water sources that have been determined by the State to be ground water under the direct influence of surface water (GWUDI). A GWUDI source refers to any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as *Giardia lamblia* or *Cryptosporidium*, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions (40 CFR 141.2). Direct influence must be determined for individual sources in accordance with criteria established by the State. GWUDI sources are subject to the treatment requirements of surface water systems.

For the purposes of this document, the term "ground water system" (or GWS) will be used to refer to a system to which the GWR applies. Key provisions of the GWR include:

- Periodic sanitary surveys of GWSs addressing eight specific sanitary survey elements to evaluate the system for the presence of significant deficiencies.
- Source water monitoring either through triggered monitoring or State-directed assessment monitoring to test for the presence of one of three fecal indicators (*E. coli*, enterococci, or coliphage).
- Requirements to correct significant deficiencies and eliminate or treat for fecal contamination through specified actions.
- Compliance monitoring to ensure that treatment technologies, installed to treat drinking water, reliably achieve at least 99.99 percent (4-log) treatment of viruses (via inactivation, removal, or a combination of these).

GWSs must comply, unless otherwise noted, with the GWR beginning December 1, 2009. The flow chart provided in Exhibit 2.1 includes a summary of the GWR requirements.

Exhibit 2.1: Summary of GWR Requirements



2.1 Sanitary Surveys

Under the GWR, States are required to conduct regular comprehensive sanitary surveys. GWSs must provide, at the State's request, any existing information that would allow the State to perform a sanitary survey. If a significant deficiency is identified, either during a sanitary survey or at any other time, the GWS is required to take corrective action. Failure to complete the required corrective action will result in a treatment technique violation. "Significant deficiencies" include, but are not limited to, defects in design, operation, or maintenance, or a failure or malfunction of the sources, treatment, storage, or distribution system that the State determines to be causing, or have the potential for causing, the introduction of contamination into the water delivered to consumers.

The sanitary surveys must be conducted, at a minimum, every three years for community GWSs and every five years for noncommunity GWSs and must include a review of eight critical elements, as applicable to the system. The eight elements are:

- Source (protection, physical components, and condition)
- Treatment
- Distribution System
- Finished Water Storage
- Pumps, Pump Facilities, and Controls
- Monitoring, Reporting, and Data Verification
- Water System Management and Operations
- Operator Compliance with State Requirements

The State may reduce the frequency of sanitary surveys for community GWSs to at least once every five years if the community GWS has an outstanding performance record as determined by the State, or the community GWS is providing 4-log treatment of viruses and conducting compliance monitoring of the treatment system under the GWR.

2.2 Source Water Monitoring

The GWR has three general categories of ground water source microbial monitoring requirements: 1) triggered source water monitoring, 2) additional source water sampling, and 3) assessment source water monitoring. GWSs conducting source water monitoring under the GWR must collect and analyze at least 100 mL of source water for one of three fecal indicators (*E. coli*, enterococci, or coliphage) using one of the analytical methods specified in the GWR.

2.2.1 Triggered Source Water Monitoring

The triggered source water provisions of the Ground Water Rule are described in Chapter 3 of this guidance manual.

2.2.2 Additional Source Water Monitoring

If the State does not require corrective action in response to a fecal indicator-positive triggered source water sample, the GWS must collect five additional source water samples from each fecal indicator-positive source within 24 hours of being notified of the fecal indicator-positive result. All five of the additional samples must be analyzed for the presence of a fecal indicator. If any of the five additional source water samples is fecal indicator-positive, the GWS must take corrective action.

2.2.3 Assessment Source Water Monitoring

As a complement to the triggered source water monitoring provision, States may require GWSs to conduct assessment source water monitoring, as needed. The purpose of optional assessment monitoring is to allow States to target monitoring of GWSs that the State believes are at higher risk for fecal contamination. As discussed in the preamble of the GWR, EPA recommends that States require systems that are conducting assessment source water monitoring to collect a total of 12 ground water source samples that represent each month the system provides ground water to the public. However, the State determines the requirements for assessment source water monitoring, including the number of samples and their sampling interval and whether one or more wells within the GWS could be sampled to physically and hydrogeologically represent multiple wells.

2.3 Corrective Action

GWSs must take corrective action if any one of the three situations applies:

- A significant deficiency is identified,
- A triggered source sample has tested positive for a fecal indicator and corrective action is required by the State, or
- At least one of the five additional source water samples collected in response to a fecal indicator-positive triggered sample has also tested positive for a fecal indicator.

If corrective action is required, the GWS must consult with the State regarding the necessary action or implement at least one of the following, as directed by the State:

- Correct all significant deficiencies
- Provide an alternate source of water
- Eliminate the source(s) of contamination
- Provide treatment that reliably achieves at least 4-log treatment of viruses at or before the first customer (using inactivation, removal, or a State-approved combination of 4-log virus inactivation and removal) and conduct compliance monitoring.

2.4 Compliance Monitoring

Compliance monitoring for the GWR refers to monitoring the effectiveness or reliability of the treatment system installed to ensure 4-log removal or inactivation, or a combination of removal and inactivation, of viruses. Only wells that provide 4-log treatment of viruses and that perform compliance monitoring are excluded from the triggered source water monitoring requirements of GWR.

To *not* be subject to triggered source water monitoring, by December 1, 2009, a GWS must notify the State that it provides at least 4-log treatment of viruses before or at the first customer. The GWS must then begin compliance monitoring by December 1, 2009. In addition, any GWS that is required to provide 4-log treatment of viruses as a corrective action must also conduct compliance monitoring to ensure that the 4-log treatment is functioning properly.

One of the compliance monitoring requirements is that GWSs that use chemical disinfection and that serve more than 3,300 people must continuously monitor their disinfectant residual concentration. GWSs must maintain the minimum disinfectant residual concentration determined by the State. GWSs that use chemical disinfection and serve 3,300 people or fewer must take daily grab samples for disinfectant residual concentration or meet the continuous monitoring requirements. If any daily grab sample measurement falls below the minimum State-required residual disinfectant concentration, the GWS must take follow-up samples every 4 hours until the residual is restored to the required level.

GWSs using membrane filtration for 4-log treatment of viruses must monitor the membrane filtration process according to State-specified monitoring requirements and must operate the membrane filtration according to all State-specified compliance requirements.

GWSs may use alternative treatment technologies (e.g., ultraviolet radiation [UV]) approved by the State, if the alternative treatment technology, alone or in combination (e.g., membrane filtration with UV) can reliably provide at least 4-log treatment of viruses. GWSs must monitor the alternative treatment according to State-specified monitoring requirements and must operate the alternative treatment according to compliance requirements established by the State.

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3. Triggered Monitoring

3.1 Overview

Under the triggered monitoring provision of the GWR, undisinfected ground water systems are triggered into taking source water samples as a result of a total coliform-positive sample in the distribution system. Any GWS that does not provide at least 4-log treatment of viruses before or at the first customer (including both treating to 4-log and demonstrating 4-log treatment by conducting compliance monitoring) must comply with the triggered source water monitoring requirement as described in 40 CFR 141.402(a). When a GWS is notified of a total coliform-positive routine sample, the GWS must collect, within 24 hours of notification, at least one sample from each ground water source in use at the time the total coliform-positive routine sample was collected, unless the system has approval from the State to do otherwise. The triggered source water sample(s) must be analyzed for the presence of a State-approved fecal indicator. If the triggered source water sample is fecal indicator-positive and the sample is not invalidated by the State, the GWS must either take corrective action, if required by the State, or collect five additional source water samples from that source and analyze them for the presence of a State-approved fecal indicator.

The triggered monitoring provision enhances the existing Total Coliform Rule (TCR). The TCR requires all public water systems (PWSs) to monitor for the presence of total coliforms in the distribution system at a frequency proportional to the number of people served. Total coliforms are a group of closely related bacteria that are (with few exceptions) not harmful to humans. Because total coliforms are common inhabitants of ambient water and may be injured (i.e., not irreparably harmed) or inactivated by environmental stresses (e.g., lack of nutrients) and water treatment (e.g., chlorine disinfection) in a manner similar to most bacterial pathogens and many viral enteric pathogens, EPA considers them a useful indicator of these pathogens. More important, for drinking water, total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system. The absence of total coliforms in the distribution system minimizes the likelihood that fecal pathogens are present, whereas the presence of total coliforms may suggest that a pathway to contamination exists. As discussed above, a GWS with a distribution system TCR sample that tests positive for total coliform is required to conduct triggered source water monitoring to evaluate whether the total coliform presence in the distribution system is due to fecal contamination in the ground water source. Triggered source water monitoring provides a critical ongoing evaluation of GWSs.

If approved by the State, systems with more than one ground water source may conduct triggered source water monitoring at a representative ground water source or sources. The State may require systems with more than one ground water source to submit for approval a triggered source water monitoring plan that the system will use for representative sampling. When it is required by the State, a triggered source water monitoring plan must identify ground water sources that are representative of each monitoring site in the system's TCR sample siting plan (40 CFR 141.402(a)(2)(ii)). If a system has a representative monitoring plan in place and encounters a fecal indicator-positive sample at representative source, the system should discuss with the State the implications for the other sources that are represented by that source. See Chapter 4 for more information about representative source water monitoring.

Source water samples should be taken from the source water well(s) for the drinking water system when possible rather than later in the distribution system, so that treatment and/or the distribution system environment do not change the character of the source water sample. This is especially true for systems that have multiple wells. The rationale is that fecal contamination among nearby wells is likely to be non-uniform in its distribution (i.e., in a group of wells drawing water from a single aquifer, it is possible that only a single well is fecally contaminated). If a system draws water from more than one well, but only a single well is fecally contaminated, the dilution of fecally contaminated water with water from other wells makes it likely that the fecal contamination would be more difficult to detect at subsequent locations downstream within the distribution system.

Because the focus of source water monitoring under the final GWR is to determine whether the source water is fecally contaminated, source water monitoring samples should not come from test, injection or monitoring wells (or well types other than production wells) because these wells may not reflect the water from the system's source water production well.

The final GWR provides States and systems with flexibility such that if a system's configuration does not allow for sampling at the well itself, the system may collect source water samples at a State-approved location, before any treatment, provided that the sample is representative of the water quality of that well as determined by the State.

3.2 Consecutive and Wholesale Systems

The GWR has additional triggered source water monitoring requirements that apply to consecutive systems and their wholesale GWSs. If a consecutive system is notified that a sample it collected for compliance with the TCR is total-coliform positive, that consecutive system is required to notify its wholesale system of the positive sample. The wholesale system is then required to perform triggered source water monitoring as described above. If a triggered source water sample collected by the wholesale system is positive for a fecal indicator, the wholesale system must notify all consecutive systems served by that ground water source of the fecal indicator source water positive result. For more information and guidance on the GWR requirements for consecutive systems, refer to EPA's *Consecutive System Guide for the Ground Water Rule* (EPA 815-R-07-020, July 2007) available at http://www.epa.gov/safewater/disinfection/gwr/pdfs/guide_gwr_consecutive-guidance.pdf.

3.3 Exceptions to the Triggered Source Water Monitoring Requirements

As indicated in 40 CFR 141.402(a)(5), a ground water system is not required to take triggered source water samples if the total coliform-positive sample is invalidated, caused by a distribution system deficiency, or collected at a location that meets State criteria for distribution system conditions that will cause total coliform-positive samples. See the next two sections for more resources and details related to these exceptions.

3.3.1 Invalidation of Total Coliform Rule Samples

Triggered source water monitoring samples are not required if the coliform sample is invalidated by the State. Under the TCR, the State may invalidate total coliform-positive samples only if (1) the laboratory establishes that improper sample analysis led to the positive result, (2) the State, based on repeat sample results, determines that the problem resulted from domestic or other non-distribution system plumbing problems, or (3) the State has substantial reason to believe that the positive result does not reflect the water quality in the distribution system. The state must invalidate a total coliform-negative sample if a laboratory observes interference with the test by other organisms. For a complete discussion on invalidation of samples under the Total Coliform Rule, please see the EPA whitepaper *Invalidation of Total Coliform Positive Samples* available at: http://www.epa.gov/safewater/disinfection/tcr/pdfs/issuepaper_invalidation.pdf.

3.3.2 Determining whether the Cause of a Total Coliform-Positive is directly related to the Distribution System

Under 40 CFR 141.402(a)(5)(i) and 141.402 (a)(5)(ii), the GWR allows States to determine that the cause of a total coliform-positive sample collected in compliance with the TCR is directly related to the distribution system and should therefore not trigger fecal indicator source water monitoring. Triggered source water monitoring is required after a total coliform-positive sample is collected from the distribution system in compliance with the TCR. A GWS may not be required to comply with the triggered source water monitoring requirement if the GWS provides documentation to the State within 30 days of the total coliform-positive sample that it met the State criteria for distribution system conditions that cause total coliform-positive samples. In addition, the State can determine that a total coliform-positive sample collected under the TCR was caused by a distribution system deficiency. To meet this Special Primacy Requirement, States must describe the criteria that will be used to determine whether a total coliform-positive sample taken under the TCR is directly related to the distribution system. States may consider that samples constitute documentation of a distribution system deficiency. For example, follow-up distribution sampling or system repair records may be useful.

Some examples are:

- If the water system is known to have recurring documented biofilm problems and the total coliform-positive sample is convincingly related to biofilm growth in the distribution system;
- After a storage tank inspection where contamination is evident;
- After main repair or repair of a storage tank;
- In a zone of the distribution system where water pressure is negative or low (e.g., less than 20 psi); or,
- When it is likely that contamination is the result of cross connection in the distribution system.

The reasons for triggered source water samples not being taken should be valid and defensible, and past distribution system problems supporting the total coliform-positive result should have been documented before the positive coliform sample result was received. For example, if a system attributes a positive total coliform result to a cross connection, the cross connection should have been previously identified and documented in writing before the positive total coliform sample was collected. In such a case, EPA recommends that a plan be put in place to address cross connecting problems.

3.4 Invalidation of Triggered Source Water Samples

If the State provides written documentation that a fecal-indicator positive sample does not reflect source water quality, or if a GWS provides the State with written notice from the laboratory that improper analysis of a sample occurred, the State may invalidate the fecal indicator-positive sample as described in the GWR (40 CFR 141.402(d) *Invalidation of a fecal indicator-positive ground water source sample.*). Within 24 hours of receiving the State sample invalidation notification, a GWS is required to take another sample and have it analyzed for the same fecal indicator.

4. Representative Source Water Monitoring

The GWR establishes a risk-targeted approach to identify and address ground water sources that are susceptible to fecal contamination. A key provision of the GWR is monitoring sources of ground water systems providing less than 4-log treatment of viruses to determine if they are fecally contaminated, as indicated by the presence of fecal indicator organisms.

Systems that provide 4-log treatment of viruses and the related compliance monitoring are not subject to the triggered source water monitoring requirements of the GWR. However, ground water sources of systems that do not provide 4-log treatment of viruses must be monitored for fecal indicators if triggered by a TCR-related total coliform-positive routine sample in the distribution system. For triggered monitoring, a GWS must collect, within 24 hours of notification of the total coliform-positive sample, at least one sample from each ground water source in use at the time the total coliform-positive routine sample was collected under the TCR, unless the system has approval from the State to conduct triggered source water monitoring at a representative ground water source or sources.

The State may require systems with more than one ground water source to submit for approval a triggered source water monitoring plan that the system will use for representative sampling. A triggered source water monitoring plan must identify ground water sources that are representative of each monitoring site in the system's TCR sample siting plan. EPA believes that this alternative can be as protective of public health as monitoring all wellheads, provided that the chosen wells are truly representative of all wellheads. In addition, for situations where a particular sample site is inaccessible, the State may identify an alternate sampling site that is representative of the water quality of the ground water at the inaccessible sample site. When considering representative sampling, EPA encourages water systems to consult the State or primacy agency early to determine if representative sampling is applicable for the system and the level of efforts and information that may be needed to ensure equivalent public health protection as monitoring all sources or wellheads.

In addition, a GWS may be directed by the State to conduct assessment source water monitoring of ground water sources that are at risk for fecal contamination. The GWR allows representative monitoring if a State requires a system to perform assessment source water monitoring and gives the GWS approval to use representative monitoring.

This chapter describes the two types of representative monitoring and presents the basic elements that GWSs should present to States when requesting permission to conduct representative monitoring. The first type of representative monitoring is based on the distribution system's water flow characteristics or hydraulics and is discussed in section 4.1 and in Chapter 5. This is applicable to triggered source water monitoring. The second type is based on the systems' sources and their physical and hydrogeologic similarity. This type of representative monitoring is discussed in more detail in section 4.2 and in Chapter 6, and applies to triggered monitoring and assessment source water monitoring. In all cases, representative source water monitoring must be approved by the State before it is implemented, and a written plan may be required to be submitted for State approval. Section 4.3 briefly addresses these plans; example plans and templates are included in Appendix A and B, respectively.

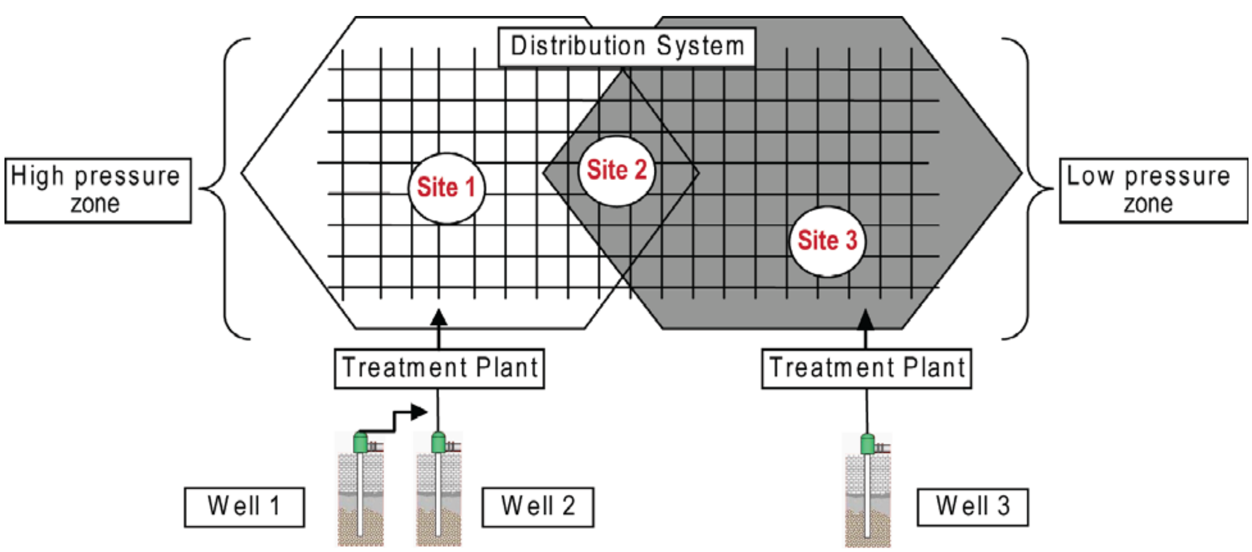
4.1 Ground Water Sources Representing Coliform Monitoring Locations in the Distribution System

A system may be able to demonstrate that a given ground water source or sources do not supply water to a section of the distribution system in which a specific TCR routine sample site is located to show that it is not likely to have contributed water to the site. In such cases, the ground water sources would not be "representative" of that TCR monitoring site, and would not have been the source of the total coliform found at that site. The State has the discretion to determine whether to require the system to take samples at such ground water source(s) when a total coliform positive is encountered in the indicated section of the distribution system.

GWSs that have hydraulically separate or distinct zones in their distribution system can request State approval of representative triggered monitoring based on an identification of which sources supply each section of the distribution system, and therefore which source(s) could potentially contribute water to each TCR routine sample site. If the system can demonstrate that the water at a TCR sampling site can only come from a subset of its sources, State-approved representative monitoring would limit triggered sampling to only those sources that could have been the source of the contamination.

Exhibit 4.1 provides an example of a system schematic that could be used to determine representative sources and develop a triggered source water monitoring plan based on where in the distribution system the total coliform-positive sample is found. If approved by the State, the system could sample wells 1 and 2 after a total coliform-positive at Site 1 since Site 1 is in the zone served by those sources. A total coliform-positive at Site 2 would require source sampling from all three wells since this area is served by all sources. If approved by the State, a total coliform-positive at Site 3 would require source sampling only from well 3.

Exhibit 4.1: Simplified Representative Monitoring Scenarios



Two additional possibilities with Exhibit 4.1 include: 1) Well 1 goes in and out of service to supplement Well 2 as needed; and 2) Well 1 is seasonal and is only used during the summer months. The GWR requires triggered monitoring at those sources "in use at the time the total coliform-positive sample was collected" (40 CFR 141.402(a)(2)). Thus, if Well 1 is not in use at the time that a total coliform positive sample is collected at Site 1, triggered monitoring would only be required at Well 2.

4.2 Wells Representative of other Wells in the same Hydrogeologic Setting

This type of representative monitoring is based on the assumption that if multiple wells feed a given TCR sample site, and they are similar enough (e.g., construction, well completion, water chemistry, etc.) and draw from the same hydrogeologic setting, the State may allow the system to sample one or more wells to represent multiple wells. This type of representative monitoring applies to both triggered and assessment source water monitoring.

As an example, the system shown in Exhibit 4.1 may provide information indicating that wells 1 and 2 are located geographically near each other, have similar well construction, and are drilled to the same depth and in the same aquifer to demonstrate that they are physically and hydrogeologically similar. In addition, the system may provide a general chemical (non-regulated constituents) screening analysis from each well demonstrating that they are also chemically similar. Based on these characteristics, the system may make a case to the State that these two wells are representative of each other, and if the State approves and if source sampling is triggered or assessment monitoring is required, the system would be able to use a sample at one well to represent both wells.

4.3 Triggered Source Water Monitoring Plan

The GWR does not require every GWS that proposes to conduct representative triggered source water monitoring to complete or submit a triggered source water monitoring plan. The State may require that a plan be developed and submitted for approval. However, even if the State does not require that the GWS prepare a plan, the GWS may wish to develop one and include the plan in its operations manual. A triggered source water monitoring plan helps to ensure that the correct source(s) is sampled without collecting unnecessary samples. The purpose of the triggered source water monitoring plan is for the GWS to have a step-by-step plan in place that identifies which sources must be sampled in response to a total coliform-positive sample at any given TCR site. It is important that the plan be readily available to water system personnel responsible for sample collection, since triggered source water samples must be collected within 24 hours of learning of the TCR routine sample result. A written triggered source water monitoring plan may be helpful to GWSs for any of the following reasons:

- If a GWS is part of a network of wholesale and consecutive systems, the triggered source water monitoring plan would provide direction as to whom should be notified and who should collect fecal indicator source water samples under different total coliform-positive scenarios.

- If the operation of the GWS is divided so that the distribution system is operated and maintained by different staff than those who operate and maintain the sources and their related treatment.
- If sample collection for the GWS is conducted by staff other than the operators (e.g., a commercial laboratory), a written plan would help the GWS and laboratory staff ensure that the proper locations are sampled.
- A written, accessible sampling plan will prevent in-house communication errors and the chance of inadequate or inaccurate sampling.
- A written plan could help assure communication among staff and delineate roles for conducting distribution system and source water sampling.

A triggered source water monitoring plan should include the following minimum elements:

1. Map or schematic of the system with sources and/or points of entry and TCR sample siting plan monitoring locations identified. The distribution system map or schematic should not contain information that poses a security risk to the system. EPA recommends that the schematic include either a distribution system schematic with no landmarks or addresses or a city map without locations of pipes indicated.
2. The source type and level of treatment provided for each source/point of entry and whether it is seasonal, emergency, ground water, surface water, a wholesale supply, etc.
3. The source(s) serving each TCR routine monitoring location and the basis for the determination (e.g., system hydraulics, operation, water quality data, etc.)
4. Any representativeness among sources based on the physical and hydrogeological properties of sources and the basis for the determination (e.g., well construction, water chemistry, aquifer type, well log, etc.)
5. For wholesale systems, the consecutive systems served and, if applicable, the sources serving each consecutive system. See *Consecutive System Guide for the Ground Water Rule* for more information on triggered monitoring as it relates to consecutive and wholesale systems. The guidance is available at: http://www.epa.gov/safewater/disinfection/gwr/pdfs/guide_gwr_consecutive-guidance.pdf
6. Any changes or variations expected in the monitoring plan such as the use of seasonal sources, rotating sources, etc.

The triggered source water monitoring plan can be a stand-alone, independent document or the system may incorporate it as part of its TCR sample siting plan. Incorporating it as part of the TCR sample siting plan may be useful because of the direct relationship that exists between TCR and GWR. In addition, many systems might need to create a multi-scenario monitoring plan to reflect the variety of ways in which their systems are operated throughout the year. For example, a GWS that uses a well field only during certain months to meet high demand may need to have one monitoring plan for those months and another monitoring plan for the others. However, where there is uncertainty of which wells are in use, a conservative approach should be used in which all potential sources are included.

Appendix A provides three examples of triggered source water monitoring plans for hypothetical systems. These examples vary in complexity and information used to justify the plan. Appendix B provides a blank template for the example plans used in Appendix A. This template is only a suggested format; each State agency may develop their own source water monitoring plan requirements.

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5. Ground Water Sources Representing Coliform Monitoring Locations in the Distribution System

Some ground water sources may be representative of certain coliform monitoring locations in the distribution system based on system hydraulics. In such cases, ground water source(s) are capable of providing water to specific TCR routine sample sites based on the hydraulics of the distribution system. Triggered monitoring requires that samples be collected from each ground water source following a total coliform-positive routine TCR sample unless the system has approval from the State to conduct triggered source water monitoring at a representative ground water source or sources.

Identifying sources that could *not* have provided water to specific sites is a recommended first step in determining whether reducing the number of source water samples that must be collected is appropriate for the GWS. The distribution system should be analyzed from a hydraulic perspective. This chapter outlines step-by-step procedures and tools that can be used to evaluate system hydraulics and provides guidance on determining whether a source is hydraulically connected to a particular TCR sampling site.

5.1 Linking Sources to TCR Sites

System design and operational practices impact the direction and velocity of flow in the distribution system. The water's hydraulic path is affected by source entry point locations, pump station operations, finished water storage tank locations, valve settings, elevations throughout the system, consumer demand, and operational settings of all tanks and pumps. Systems will typically be knowledgeable of their distribution system configuration and will generally have a good understanding of water movement in their system. However, for the purposes of representative sampling, it is important to definitively determine which ground water source or sources could provide water to each routine total coliform sample site and which sources could not have provided water.

Those sources that are unlikely to have provided water to a sampling site may be excluded from being a representative location for triggered monitoring, if approved by the State. All other sources that could provide water to the coliform sample site are thereby linked to that site. In some instances, water flow from one zone to another is possible but generally unlikely during normal operating conditions. To ensure that the appropriate sources are sampled if monitoring is triggered, systems should eliminate only those sources that clearly cannot provide water to the coliform sampling site.

This kind of knowledge is helpful in preparing a satisfactory plan. If the system does not understand the issues well, it should not consider a representative monitoring plan or should consider hiring experts to help to prepare it. Simple water systems with uncomplicated distribution systems will likely be straight-forward to evaluate, while those that are more hydraulically complicated will likely require more advanced analysis of water movement, especially in cases with very extensive delineation of hydraulic zones and separation of sources from zones. In either case, when considering representative sampling, EPA encourages water systems to consult the State or primacy agency early to determine if representative sampling is applicable for the system and the level of efforts and information that may be needed to ensure equivalent public health protection as that achieved by monitoring all sources or wellheads. The following is a general step-by step process for linking sources to TCR routine sample collection sites:

1. Map what is already known. Water systems should work with the State or primacy agency to determine the amount of effort to invest in additional studies of their distribution systems and sources. The various maps of system water quality, pressure zones, etc. that are applicable are discussed in section 5.2.1.
2. Superimpose the routine sample collection sites for the TCR-related sample siting plan on the distribution system map. For many systems, this step will have already been completed as part of developing the initial sample siting plan. Coliform sample siting plans are discussed in section 5.2.2.
3. Review operations records. Historical operations records, such as well pumping compared to tank levels and controls, may provide insight into water flow patterns under typical operating conditions. See section 5.2.3.
4. Apply information from a hydraulic model, if available. The modeled results may be useful when gathering data to make a case for representative source water monitoring. See section 5.2.4 for more on hydraulic models.
5. Review water quality parameter data. Distribution system water quality parameter data may be helpful if the system's water sources are of differing water quality. This information may help to identify sources that serve specific coliform sample sites and is discussed in section 5.2.5.

5.2 Tools

Ground water systems should have a wide variety of tools available to evaluate the distribution system to determine which sources contribute to each TCR site. In some instances, States may determine that information from simply locating sources, entry points, and TCR sites on the distribution system map is adequate. In other cases, States may require that additional information from hydraulic models or tracer studies be used to confirm whether sections of the distribution system are hydraulically separated.

5.2.1 Distribution System Maps

The most critical tool available to begin analyzing how water moves in a water system and identifying hydraulically separated pressure zones is a distribution system map.

Many distribution systems have distinct zones that allow water movement to be managed. Zones can be created and managed to maintain a constant range of pressures in a distribution system with different elevations. Valves, pumps, and storage facilities all provide ways for a distribution system to maintain different zones and, as a result, reliable water system pressure.

Control valves, such as pressure reducing valves and gate valves, are used to regulate flow or pressure in a distribution system. Locations of valves and how they are operated influence whether water in different parts of the distribution system mixes significantly. Valves that are improperly maintained and exercised may leak and not serve as reliable tools for isolating different zones. Valve condition, therefore, should also be considered, as should records of regular valve exercising and inspections.

Pumps are often used in distribution systems to boost water to higher elevations or increase pressure. Another way to satisfy the need for adequate capacity and pressure is to use standpipes, elevated tanks, and large storage reservoirs. Knowing the locations, specifications, and condition of the valves, booster pumps, and storage facilities that comprise the distribution system is important for personnel who are trying to characterize its water movement.

A system map may be as simple as a schematic or a street map or may be quite detailed and based on as-built drawings and system surveys. Any distribution system map or schematic that is shared outside of the water system should not contain information that poses a security risk to the system. EPA recommends that such schematic include either a distribution system schematic with no landmarks or addresses or a city map without locations of pipes indicated. The following locations should be indicated on the map or included with the map:

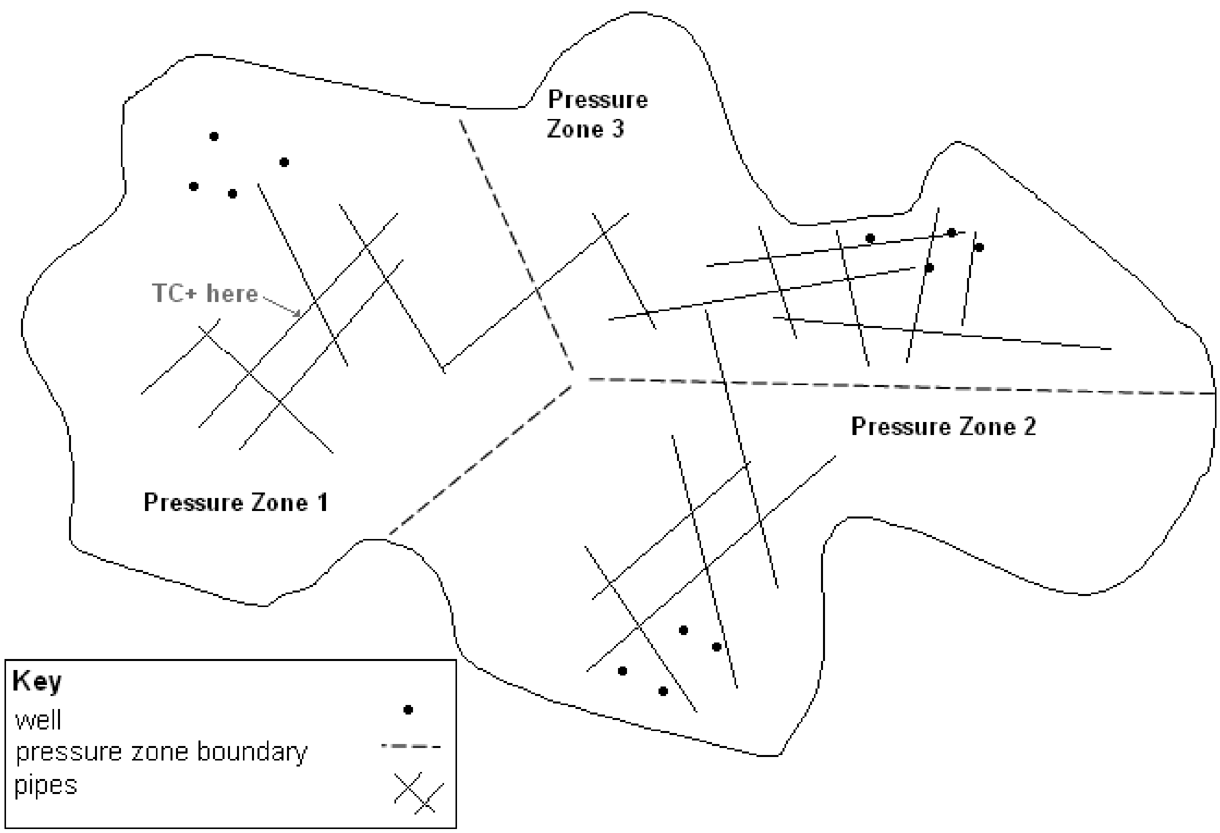
- All water source entry points including any interties (i.e., interconnections) with other water systems.
- Treatment facilities and the extent of treatment provided.
- All routine total coliform sampling sites with an identifying number.
- Storage tanks / reservoirs.
- Pressure regulation facilities (reducing stations).
- Other infrastructure that may affect pressure and/or flow in the distribution system.
- Booster pump stations.
- Pressure zone boundaries.
- Transmission lines (the pipeline or aqueduct used for water transmission of water from the source to the treatment plant and from the plant to the distribution system [AWWA, 2003]).
- Critical valves (those valves whose function is vital to the successful operation of the system or whose failure can lead to serious consequences [Dorf, 2005]).

The system map should reflect operational changes that have altered the hydraulic zones linked to each TCR site. It may be helpful to prepare a summary table listing each source and the pressure zone(s) it serves.

Exhibit 5.1 illustrates a simple multi-pressure zone distribution system map. Assume that all pressure zones are hydraulically separated as demonstrated by evidence presented by the system (e.g., significant differences of elevations among pressure zones, presence of closed valves among zones, other supporting data, etc.) and source sampling has been triggered by a total coliform positive result in Zone 1. Representative monitoring based on system hydraulics could specify that only the wells in Zone 1 must be sampled (because wells in Zones 2 and 3 do not contribute to Zone 1 and are therefore not representative of Zone 1).

Chapter 6 explains how the case for representative monitoring can be further developed to include wells representative of other wells within the same hydrogeologic setting. For example, consider a system that is required by the State to develop a triggered source water monitoring plan to qualify for representative source water monitoring. If the system presents supporting information, and the State agrees, that two or more of the wells in pressure Zone 1 are representative of each other, then the triggered source water monitoring plan could specify that fewer than all 4 wells would need to be sampled. In this case, the water quality of the sampled wells would be representative of that of the unsampled wells. However, if the wells in pressure Zone 1 are not shown to be similar enough based on their physical and hydrogeological properties then all of the wells in pressure Zone 1 would need to be sampled.

Exhibit 5.1: Example Distribution System Map



5.2.2 Coliform Sample Siting Plan

Each ground water system should have a coliform sample siting plan as required by 40 CFR 141.21(a). The purpose of this sample siting plan is to identify sites throughout the distribution system that are representative of the water quality of the entire distribution system. An analysis of which sources feed each section of the distribution system may have been completed in developing the coliform sample siting plan since it is necessary to identify sampling sites that are hydraulically upstream and downstream from the routine total coliform monitoring sites. If available, this analysis could be useful during the development of the triggered source water monitoring plan.

The coliform sample siting plan typically includes a map and an address list of routine, upstream, and downstream sample sites with descriptions of tap locations. Example information is listed in Exhibit 5.2.

Exhibit 5.2: Total Coliform Sample Site Locations

	Primary Location		Upstream Location	Downstream Location
Site ID	**Name**	**Tap location**	**Name**	**Name**
1H-1	FH #9, 1617 U St. NW	Bathroom in Officer's room	V Best Supermarket 1507 U St NW	Keren Restaurant 1780 Florida Ave NW
1H-18	Bread for the City, 1525 7th St. NW	Hose bib	Dollar Plus Savings Store 1541 7th St. NW	Kennedy Recreation Center 1401 7th St. NW
1H-2	FH #16, 1018 13th St. NW	Bathroom sink	Stoney's Beef and Beer 1307 L St NW	Roy Rogers 1275 K St NW
1H-3	FH #1, 2225 M St. NW	Kitchen sink	Federal Market 1215 23rd St NW	Medical Society of DC 2215 M St NW

5.2.3 Operating Conditions and Operations Records

Another resource may be historical operations records such as tank levels and pumping data and interviews with system operators. For example, a review of well pump status (whether the well pump is operating) and tank level data (whether the tank is filling) for the same time period can indicate which area is served by each well, after taking consumer demand into consideration. System operators generally have an understanding of which sources serve which parts of the distribution system based on their experience with pump controls and related telemetry. System operators should use available records and/or observations to support this understanding. When operations records and operator experience indicate that the areas served by ground water sources are not clearly delineated, additional information is likely required to determine whether hydraulically representative monitoring is feasible.

In situations where sources go in and out of service or where other operating conditions regularly change, systems should discuss with the State the appropriateness of having different representative monitoring plans under different operating conditions, what measurable criteria should be included to define when the conditions change and new representative sources apply, and how many variations might be acceptable.

5.2.4 Distribution System Hydraulic Models

Hydraulic modeling can be used to determine the flow path from one point to another in a distribution system. For example, it can be used to determine the upstream hydraulic path from the routine total coliform sampling site to the source(s) of supply. In order to give accurate results, the hydraulic model should meet these criteria (Martel et al. 2005):

- The model is calibrated.
- Demand patterns are accurately detailed.
- The model is regularly updated to reflect changes in the hydraulic configuration of the system.
- The model provides more than a "skeleton" view of the distribution system.

Some utilities have used hydraulic models to meet the requirements of the Stage 2 Disinfection Byproducts Rule (Stage 2 DBPR) Initial Distribution System Evaluation. In this evaluation, the hydraulic model estimates water age throughout the distribution system. Systems may be able to utilize the work completed for Stage 2 DBPR to confirm which source or sources contribute to a routine total coliform sampling site.

Hydraulic modeling may not be available to most small groundwater systems, but it may not be necessary for some ground water systems with simple distribution systems. However, the benefits of using a hydraulic model in order to justify representative monitoring may be clearer to other systems such as very complex systems with numerous pressure zones.

5.2.5 Distribution System Tracer Studies

A tracer study may help a system to better understand the paths and destinations that water takes from a source to various points throughout the system and the proportion of that water taking a particular path. These studies involve adding a chemical such as fluoride to the distribution system at one point, and measuring the chemical concentration at downstream points to estimate the travel time between the two points. After the tracer is added, the operator should sample in the distribution system to determine how levels of the tracer appear and then diminish over time, providing an indication of the water's age and the area served by the source. If the system already adds fluoride to the water, it is possible for the tracer study to be conducted by stopping the fluoride feed in one source at a time and measuring the decreasing fluoride concentration at downstream points.

For the purposes of a triggered source water monitoring plan, one recommended approach is to add the tracer at one source and not at others, with monitoring throughout the distribution system to identify areas where the tracer appears. Tracer studies should be done with some care, however, to consider consumer demand, finished water storage influences, and other source water pumping, so that a valid assessment of the area served by the investigated source can be made with confidence. Systems considering a tracer study should contact their State prior to beginning the study and the tracer used should be approved for use in potable water supplies.

5.2.6 Customer Complaint Records

Customer complaints records sometimes function as a sentinel for water utility personnel. These records can reveal water quality issues overlooked by sampling and other barriers that are in place to protect public health. The TCR white papers (available at http://www.epa.gov/OGWDW/disinfection/tcr/regulation_revisions.html) include several examples in which water quality issues correlate with customer complaints. Customer complaints may supplement other tools mentioned above to help the States or primacy agency to determine if representative monitoring sampling is appropriate for a system. For instance, if the utility is receiving the same types of customer complaints from two areas, this may be an indication that the areas may be connected or are receiving water from the same source. In this case, the system should utilize other tools to investigate the problem and confirm whether the areas are actually hydraulically linked.

Customer complaint records may also be helpful in identifying areas in which different sources are mixing. If the distribution system is fed by multiple sources with varying water quality, the release of biofilms, scales, or sediments may occur where different sources blend. For example, the City of Tulsa, Oklahoma, found that the majority of positive coliform samples that were detected over a two-year period occurred at the interface between two treated waters in the distribution system (Kirmeyer et al. 2000). Customers in this area of blended water complained of red or brownish water that may have been caused by loosening or dissolution of scale material due to changing water quality. In such areas where mixing occurs, water is coming from more than one source. This should be considered when determining which wells to sample when triggered source water monitoring is required.

5.2.7 Water Quality Parameters

Water quality varies with each source of supply. The source water may or may not contain dissolved minerals, dissolved gases, organic matter, or combinations of these constituents that can be used to distinguish one source from another, or to link the source to a particular routine total coliform sample site. For example, ground water from wells tends to contain more dissolved minerals than either lake or river water since the groundwater seeps through minerals in the earth.

If available, the following water quality parameters may be used to help to characterize a ground water source and link it to coliform sites if the same parameters are also monitored at the sample collection sites:

- Total hardness as calcium carbonate
- Alkalinity as calcium carbonate
- Conductivity
- Chlorides
- Fluoride
- Nitrates
- Phosphate
- Sulfate
- pH
- Total dissolved solids
- Aesthetic quality of water (e.g., taste, color, or odor)
- Water temperature

If the system is unsure whether a source feeds a certain area of the distribution system, and they have a well or well field with water quality characteristics that are unique to that site, they may conduct monitoring in the distribution system to determine where in the distribution system those same characteristics are found. For instance, if a system has one set of wells with relatively high sulfate levels and the other sources have low levels, sulfate sampling in the distribution system may help clarify whether that source contributes water to that part of the distribution system.

5.3 Considerations While Preparing a Plan

This section discusses considerations that may be useful when developing a triggered source water monitoring plan. As discussed previously, the State may require systems with more than one ground water source to submit for approval a triggered source water monitoring plan that the system will use for representative sampling. If a plan is not required, the system may still wish to consider the same criteria described here in determining whether representative monitoring is appropriate. In either case, EPA encourages water systems to consult the State or primacy agency early to determine if representative sampling is applicable for the system and the level of effort and information that may be needed to ensure equivalent public health protection as that achieved by monitoring all sources or wellheads.

Once the system has pulled together the tools available to help determine which sources feed each routine total coliform sampling site, the next step is to begin to prepare the triggered source water monitoring plan. The system should start by reviewing the system map to identify any areas of the distribution system that are clearly and defensibly hydraulically separated.

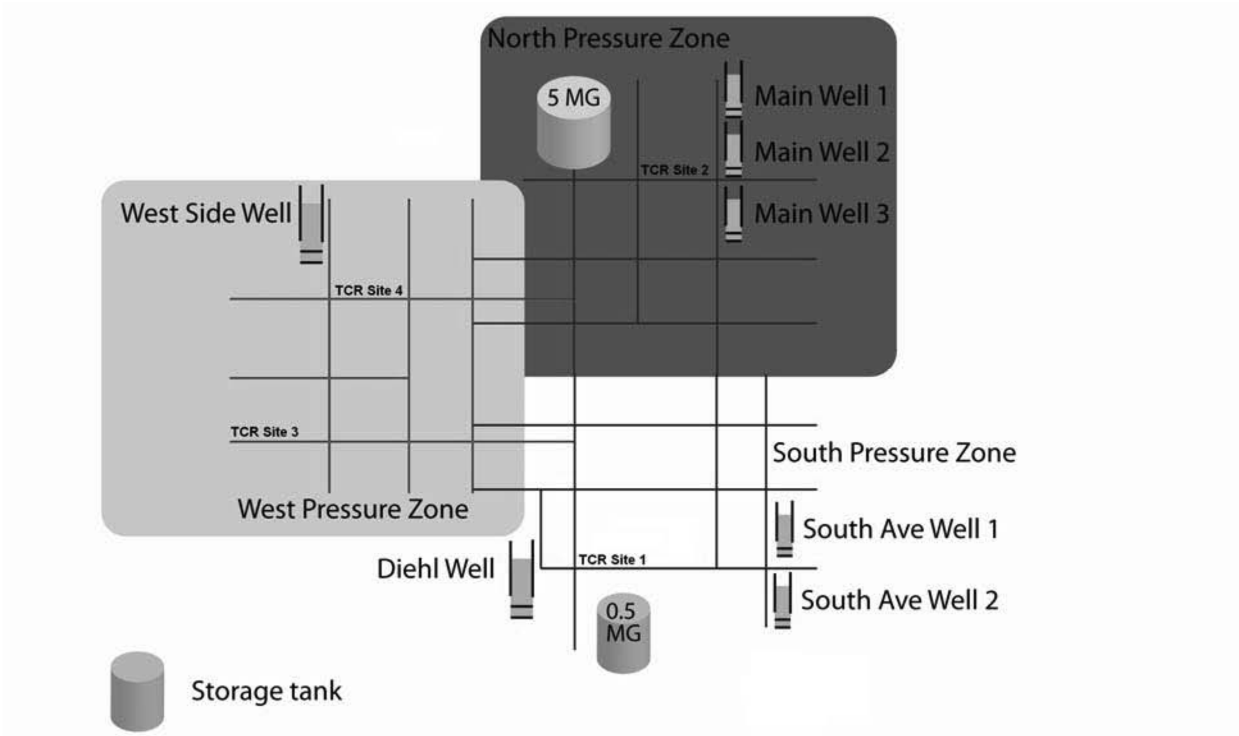
The plan should include a distribution system map that identifies all sources, critical infrastructure such as tanks and pump stations, delineation of pressure zones, identification of system elevations, and all routine total coliform sampling sites. The plan should also provide a discussion of how the link from each source to each site was determined.

When determining which sources do not require sampling after a total coliform-positive sample, the system should take a conservative approach. For example, sources should only be excluded if there is very little or no likelihood that water from that well can contribute to the mix of water at the sample location.

The example in Exhibit 5.3 provides a simple schematic of a distribution system along with a table identifying each routine total coliform sampling site and identifying sources that can supply water to each site. In this example, the South Pressure Zone is at a lower elevation than both the West Pressure Zone and the North Pressure Zone, and the West Pressure Zone is at a lower elevation than the North Pressure Zone. Using their understanding of hydraulics, the operators reasoned that water flows from the North Pressure Zone to both the West and South Pressure Zones and that water flows from the West Pressure Zone to the South Pressure Zone. This assertion can be further supported by conducting tracer studies. The case for hydraulic separation is strengthened if (1) a tracer is introduced into the South Pressure Zone, and it is not detected in either the West Pressure Zone or the North Pressure Zone and (2) a tracer is introduced into the West Pressure Zone, and it is not detected in the North Pressure Zone.

The next section of this manual will build on this example by discussing criteria for identifying whether wells are representative of each other based on physical and hydrogeological properties.

Exhibit 5.3: Example Triggered Source Water Map and Table



TCR Site	Pressure Zone	Contributing Wells
1	South	South Ave Well 1 South Ave Well 2 Diehl Drive Well Main Well 1 Main Well 2 Main Well 3 West Side Well
2	North Central	Main Well 1 Main Well 2 Main Well 3
3	West Side	Main Well 1 Main Well 2 Main Well 3 West Side Well
4	West Side	Main Well 1 Main Well 2 Main Well 3 West Side Well

References

AWWA. 2003. *Water Transmission and Distribution (Water Supply Operations Training), 3rd Edition.* American Water Works Association.

Dorf, Richard C. 2005. *The Engineering Handbook*. Boca Raton, Florida. CRC Press.

Iowa Department of Natural Resources. *Groundwater Basics Occurrence, Movement, and Quality*. Available at: http://www.igsb.uiowa.edu/GWBASICS/Chapters/Groundwater%20Basics%20Occurrence%20Movement%20and%20Quality.pdf

Kirmeyer, G., M. Friedman, J. Clement, A. Sandvig, P. Noran, K. Martel, D. Smith, M. LeChevallier, C. Volk, E. Antoun, D. Hiltebrand, J. Dyksen, and R. Cushing. 2000. *Guidance Manual for Maintaining Distribution System Water Quality*: CD-ROM. AWWA Research Foundation. Denver, CO.

Martel et al. 2005. Data Integration for Water Quality Management. Denver, Colo.: AwwaRF.

6. Wells Representative of Other Wells in the Same Hydrogeologic Setting

A public water system may request that one or more wells be considered representative of multiple wells' risk for fecal contamination based on physical and hydrogeological evidence. If approved by the State, the system may not need to sample all of the wells that serve a TCR site when triggered source water monitoring is required. This representativeness based on physical and hydrogeological properties may also reduce the source water monitoring burden that applies to assessment source water monitoring directed by the State. When considering representative sampling, EPA encourages water systems to consult the State or primacy agency early to determine if representative sampling is applicable for the system and the level of effort and information that may be needed to ensure equivalent public health protection as that achieved by monitoring all sources or wellheads.

Wells that are determined to be representative of each other based on physical and hydrogeological properties should have similar well construction, draw water from the same hydrogeological setting, and have the same vulnerability to fecal contamination. It is important to emphasize that even wells that appear nearly identical in location, construction, and water chemistry (their physical representativeness), and that tap the same aquifer (their hydrogeological representativeness), may have different vulnerabilities to fecal contamination based on their distance to source(s) of fecal contaminants and the wells' recharge zones. Any one of these items may provide information that indicates wells under evaluation are ***<u>not</u>*** representative of each other. The State or primacy agency may determine that wells are not representative of each other based on any one of these criteria. This chapter discusses the information that systems could use to determine whether wells are representative of other wells, and presents a decision-making approach that removes from further consideration sources that do not meet any one of these suggested criteria.

Total coliform monitoring data and heterotrophic plate count bacteria (HPC) data are not included as information useful to decision makers of representative monitoring programs since an absence of these microbes is generally expected for ground water sources. Wells with a history of total coliform organisms or elevated HPC levels should be monitored for fecal indicator organisms. In addition, an absence of total coliforms should not be interpreted to mean a fecal indicator would also be absent. A viral pathogen may be present even though bacterial indicators are not detected.

6.1 Physical Properties

To begin to inform whether wells have the same risk for fecal contamination, physical properties of the wells should be evaluated. Physical similarities described in this chapter address the proximity of the wells, their construction, and the water chemistry of the wells.

6.1.1 Well Proximity to other Wells

Because fecal contamination in an aquifer can be localized, a relatively easy aspect for a system to consider would be the physical proximity of the wells. Although any representative scheme will be at the discretion of the State and based on the professional judgment of State and system personnel, a general rule of thumb is that the farther the geographical/physical distance between two sources, the less likely that one source can represent the fecal contamination risk or water quality at the other. The consideration of well separation distances are system and source-specific.

Some systems may have supply wells located intermittently throughout a community. Wells spaced intermittently throughout a community are unlikely to be good candidates for representative sampling if there are great distances between them. The assumption that wells that are relatively distant from one another are not representative of one another may generally be true for shallow wells or hard rock wells common in the Eastern U.S. However, this may not be true for the large, deep wells commonly found in the Western U.S.

Systems having well fields or clusters of wells are likely to have wells located relatively close to one another. These wells may be excellent candidates for representative sampling if they are able to meet the other physical and hydrogeological criteria.

6.1.2 Well Construction

Well construction information is vital to the process of designating representative wells. Well construction refers to many aspects including the drilling method, depth of the well, grouting depth, the screened interval, and the condition of the sanitary well seal. Cracks in well casings, failure of a subterranean vent or other construction problem may occur in one well and not others and not be observed from the ground surface. Therefore, determining that a particular well is representative of other wells should reflect an understanding of well construction or condition. Differences in these physical characteristics of a well would render some wells more susceptible to contamination than others, particularly if contaminants could enter the well through means other than via the aquifer. Poorly constructed wells have higher probability or risk to contaminate. For example, surface runoff may enter the well down the casing of a poorly constructed well. Representative sampling would be inappropriate for wells with different construction.

Drillers' logs provide important information not only on the location of the well, geologic descriptions that aid in determining the aquifer type from which the well draws water, and the depths of screened intervals, but also information on the casing and grouting, which can help States and systems evaluate well integrity. If drillers' logs are not available for each of the wells, it will be difficult for primacy agencies to approve representative sampling for those wells.

The importance of considering information from drillers' logs on the depths of screened intervals is demonstrated in Exhibits 6.1 and 6.2, below, which show a cluster of three wells at an airport that are very close to each other at the surface. In Exhibit 6.1, the wells are likely to be good candidates for representative sampling because the wells are similarly constructed and screened at the same depth. Drillers' logs would be the primary way of identifying the problem in Exhibit 6.2, where although the wells are close at the surface, they are drawing water from different depths in the aquifer, and, in the case of one well, from a different aquifer altogether. Such wells would not be good candidates for representative sampling.

States may require information in addition to well location, construction, and drillers' logs to approve representative sampling.

Exhibit 6.1: Potentially Good Candidates for Representative Sampling

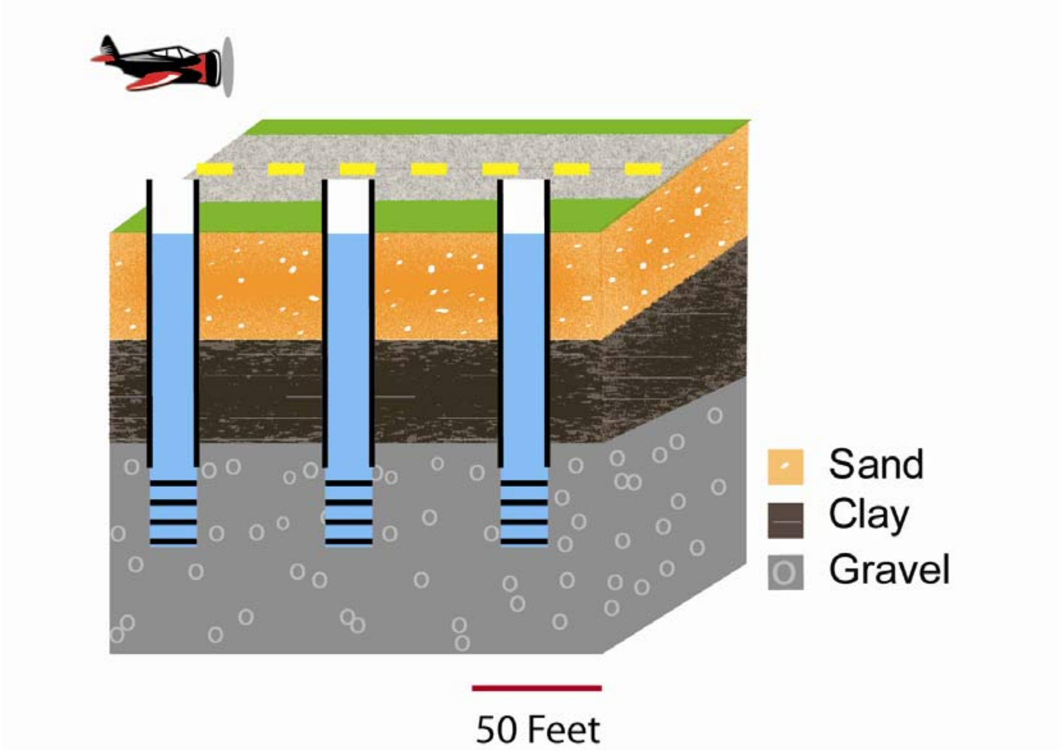
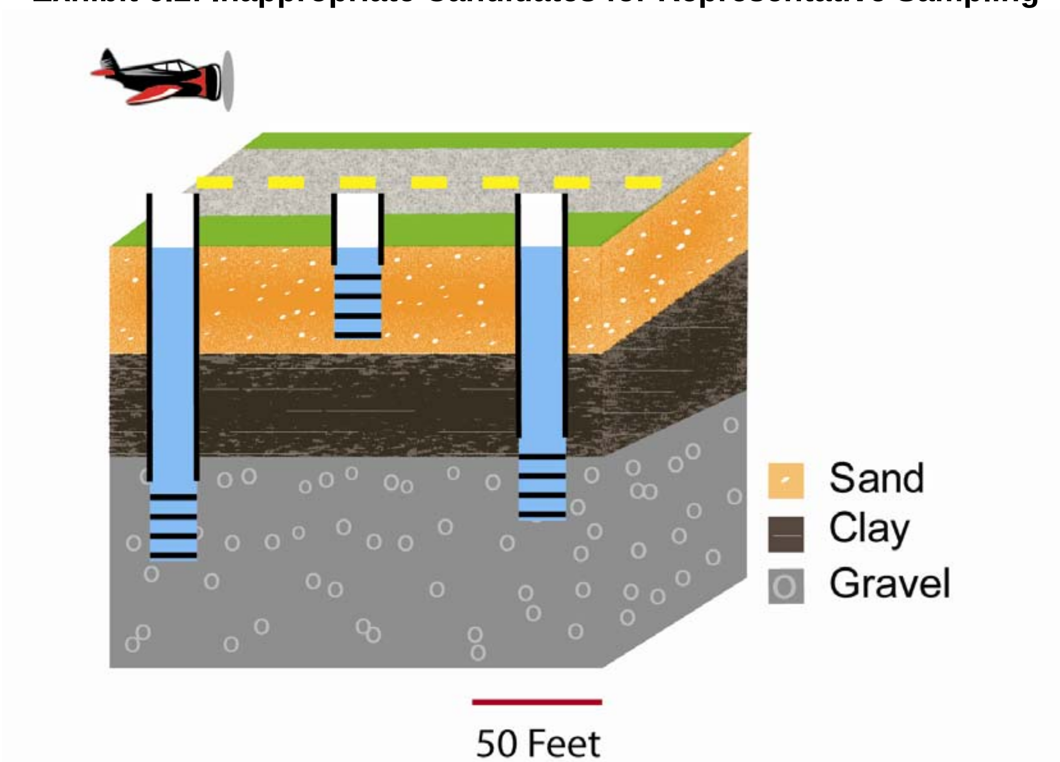


Exhibit 6.2: Inappropriate Candidates for Representative Sampling

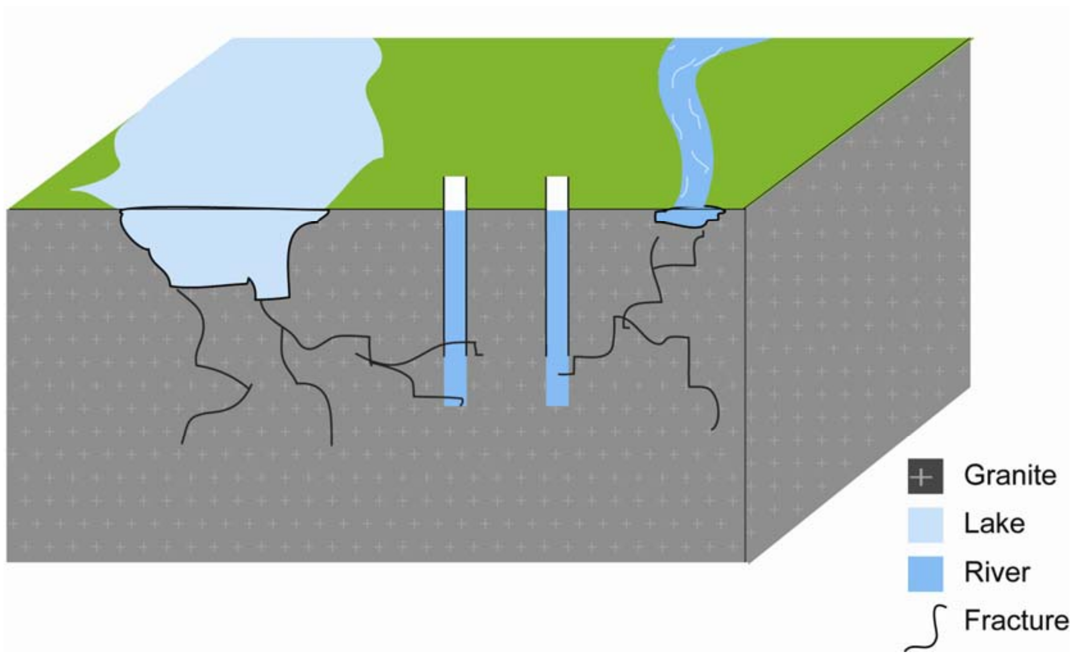


6.1.3 Water Chemistry

Source water chemistry data can be an excellent tool in providing evidence that two or more wells are or are ***not*** representative of each other. Water chemistry comparisons may be as simple as evaluating basic chemical screens that capture total dissolved solids, hardness, and sodium, or may include more elaborate monitoring data information. Wells located close to each other, even those that are screened at the same depths, but that have significantly different source water chemistries, may be drawing water from different subsurface sources, given that subsurface hydrogeology may be very complex.

For example, in fractured bedrock, one of the most complex of subsurface environments, two subsurface fractures that are very close to each other (even only feet or inches away from each other) may be hydraulically disconnected, with each fracture containing water from one of two near-surface sources that are very far apart (see Exhibit 5.3). In this case, two wells that are near to each other and screened at the same depth (but, unbeknownst to the system, drawing water from the two hydraulically disparate fractures), could have remarkably different source water chemistries and vulnerability to fecal contamination, and thus could not be considered representative of each other.

Exhibit 6.3: Wells in Close Proximity Not Representative Due to Fractured Bedrock



Three particular types of source water chemistry data are discussed below. A State or system may have one, all, or some of these indicators on which to base a decision about representativeness. Additional types of source water chemistry data may be available to assist in determining if wells are representative of each other. Significant differences in TDS or nitrate levels among wells suggest that wells are not representative of each other. The State may determine that because all wells have certain levels and types of TDS or nitrates (whether those levels are similar or dissimilar among wells) that all wells should be sampled under the triggered source water monitoring requirement of GWR because the State may determine that the TDS and nitrates in the wells are tied to pathways or potential sources of fecal contamination.

Because considering multiple chemical indicators (as opposed to one) provides a greater degree of confidence regarding a decision about wells being representative of each other, States may require additional information during the approval process.

6.1.3.1 Total Dissolved Solids

Total Dissolved Solids (TDS) is a measure of the amount of solid material that has been dissolved in water. TDS can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions.

Sources of TDS in ground water include the solid material of the aquifer itself and non-point source pollutants such as road salt, lawn fertilizer, and septic system effluent. Much of the TDS found in ground water samples may also be used to indicate proximity to a surface water source. This may be important if fecal contamination in the surface water could reach the ground water source.

Wells with significantly dissimilar TDS contents should not be treated as representative of each other. However, caution should be applied in using similar TDS data to determine whether wells *are* representative of each other. Water samples with similar TDS values may in some cases have different major ion contents that happen to add up to similar TDS values (in which case the wells from which the samples were taken would not be representative of each other).

6.1.3.2 Nitrates and Ammonia

Because excessive levels of nitrate in drinking water have caused serious illness and sometimes death, it is a regulated contaminant for all public water systems and is commonly monitored at the source water entry point to the distribution system. Nitrate is also fairly easy to test for. Thus, nitrate data may be one piece of evidence in an investigation of whether two or more wells should be considered representative of one another, particularly if wells have comparable and low levels of nitrate.

Nitrate is derived from nitrogen, which is present in fertilizers and animal manure. Airborne nitrogen compounds from automobile and industrial emissions can also contribute to nitrate in ground water. (In general, nitrogen is converted to nitrate in natural waters.) In residential areas, lawn fertilizers, septic systems, and pets are common sources of nitrates, whereas in agricultural areas nitrates are even more common due to frequent application of fertilizers. Nitrates generally persist in ground water for decades (USGS, 1988).

In many rural areas in the U.S. in which wastewater is treated through individual on-site septic systems, elevated nitrate levels can be used as an indicator of possible wastewater influence. If two or more wells have elevated levels of nitrate, this may be an indication that wastewater has contaminated the aquifer and pathogens may be present. Because pathogens tend to be less uniformly distributed in an aquifer than nitrates, elevated nitrates in two or more wells is not a good reason to consider the wells representative of each other. Thus, except in those cases where fertilizer or other background concentrations of nitrate are the cause of the elevated concentrations in samples, elevated nitrates in samples from wells indicates a need for more sampling of the aquifer, not less. In summary, if the source of the nitrate is wastewater or animal manure, it would not be prudent to rely on representative monitoring to eliminate one or more of the high nitrate wells from sampling for fecal indicators.

Comparisons of ammonia data between two wells may be a better indicator of whether the wells are representative of one another than comparisons of total nitrate concentrations. This is because ammonia converts to nitrate after a short time, so the presence of ammonia indicates a recent influx of ammonia. Nitrates, being longer-lived and also attributable to a variety of sources, are commonly found in many wells. Thus, when available, ammonia data is preferred to nitrate data for determining representativeness. Information on typical nitrate levels for the aquifer may not be readily available to the operator. The system should consult with the State drinking water office, State geologist, or local USGS office for more information and possible assistance with interpreting results.

6.1.3.3 Hardness and Alkalinity

Ground water samples from wells being considered for representative sampling can be analyzed for parameters such as hardness, alkalinity, major cations, and major anions. As discussed above, additional source water chemistry data provide a greater degree of confidence regarding a decision about representative source water sampling. Hardness and alkalinity are both commonly (and easily) measured when characterizing water chemistry and can provide additional evidence when evaluating samples for similar chemistry. Hardness indicates the mineral content of the water and is determined primarily by the concentrations of calcium and magnesium ions. It is expressed in terms of mg/L of calcium carbonate. Groundwater that has flowed through limestone commonly has high concentrations of these ions, and thus is very hard (Freeze and Cherry, 1979). Alkalinity is calculated as the sum of the bases in water and provides an indication of the ability of the water to buffer acidity. In most natural waters, alkalinity is approximated by the sum of the concentrations of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions (Drever, 1988). These constituents are represented on both Piper and Stiff diagrams.

Piper diagrams (Piper, 1944) and the Stiff diagrams (Stiff, 1951) are graphical methods for displaying the chemical composition of water samples. Multiple samples can be plotted on each type of diagram, allowing for quick visual comparison of water chemistry from different sources. As such, Piper and Stiff diagrams are useful tools for evaluating the degree of similarity among water samples. Samples from wells being considered for representative sampling should have very similar results when ion concentrations are plotted on the Piper and Stiff diagrams.

The Piper diagram is the most widely used graphical method of representing the relative proportions of the major ionic species (Güler, et al., 2002). The diagram consists of two ternary plots, one for the major cations (with Ca^{2+}, Mg^{2+}, and $Na^+ + K^+$ on the axes) and one for the major anions (with $HCO_3^- + CO_3^{2-}$, SO_4^{2-}, and Cl^- on the axes). The points from the two ternary diagrams are then projected onto a third, diamond-shaped plot, which displays the overall chemical character of the sample. Samples with similar chemical compositions will result in points that are clustered together on the final diagram. The Stiff diagram also displays concentrations of the major ionic species, but the values are displayed along a horizontal axis. Concentrations of the major cations are plotted on the left side of the axis, and concentrations of the major anions are plotted on the right side of the axis. Pairs of ions or ion groups are plotted opposite each other (i.e. $Na^+ + K^+$ vs. Cl^-, Ca^{2+} vs. $HCO_3^- + CO_3^{2-}$, and Mg^{2+} vs. SO_4^{2-}) and the points are connected to create a polygon. Samples with similar chemical compositions will result in similarly-shaped polygons. Figure 1 from *Hands-on laboratory exercises for an undergraduate hydrogeology course* (Lee, 1998) provides an example Piper and Stiff diagram.

6.2 Hydrogeological Representativeness

The following sections discuss desktop sources and types of hydrogeologic information that is available for helping to make decisions on the representativeness of wells. These sources can provide information on aquifer type as well as confining layer information. Other factors, such as heterogeneity and anisotropy (directional dependence) of the aquifer from which the well produces water, may affect the capture zones of individual wells such that wells within a well cluster are not very representative of one another. Thus, it is important to use a weight-of-evidence approach to determining which wells are good candidates for representative sampling.

States and systems should make use of all available data, including well location, depth of the screened intervals, well construction, aquifer properties, water chemistry data, etc. The additional information on more complex hydrogeological analyses provided in section 6.2.2 may not be useful or necessary for most systems but is provided here to accommodate those that will find it beneficial.

6.2.1 Aquifer Type and Driller's Logs

Data on aquifer type can be useful when determining if two or more wells can be considered representative of one another. States should consider the information along with the hydrogeology of the site as a whole, including the type of confining layer overlying the aquifer in question.

For example, two wells screened in a karst aquifer overlain by a continuous confining layer (Exhibit 6.4) are more likely to be representative of each other than two wells screened in a karst aquifer overlain by a discontinuous confining layer (Exhibit 6.5). This is the case even if in both scenarios the two wells are fairly close to each other, both in horizontal distance and in the vertical separation of the screened interval of each well. This is because the discontinuous confining layer may not be providing the same level of protection to all wells because it is discontinuous. A continuous barrier protects all wells equally while a discontinuous layer may allow contamination to enter one well more easily than another.

When wells draw water from fractured bedrock aquifers, it is difficult to determine the direction of ground water flow and vulnerability to sources of contamination. It is also very likely that nearby wells (both drawing from fractured bedrock aquifers) are producing water of markedly different quality, or at least markedly different vulnerability to contamination. Thus, wells in fractured bedrock aquifers are among the worst candidates for representative sampling, and only in rare cases where systems have fairly detailed knowledge of subsurface conditions should representative sampling be considered in fractured bedrock aquifers. Operators who need assistance should consult with the State drinking water office, State geologist, or the local USGS office for possible assistance with interpreting results.

Exhibit 6.4: Wells Screened in a Karst Aquifer Overlain by a Continuous Layer

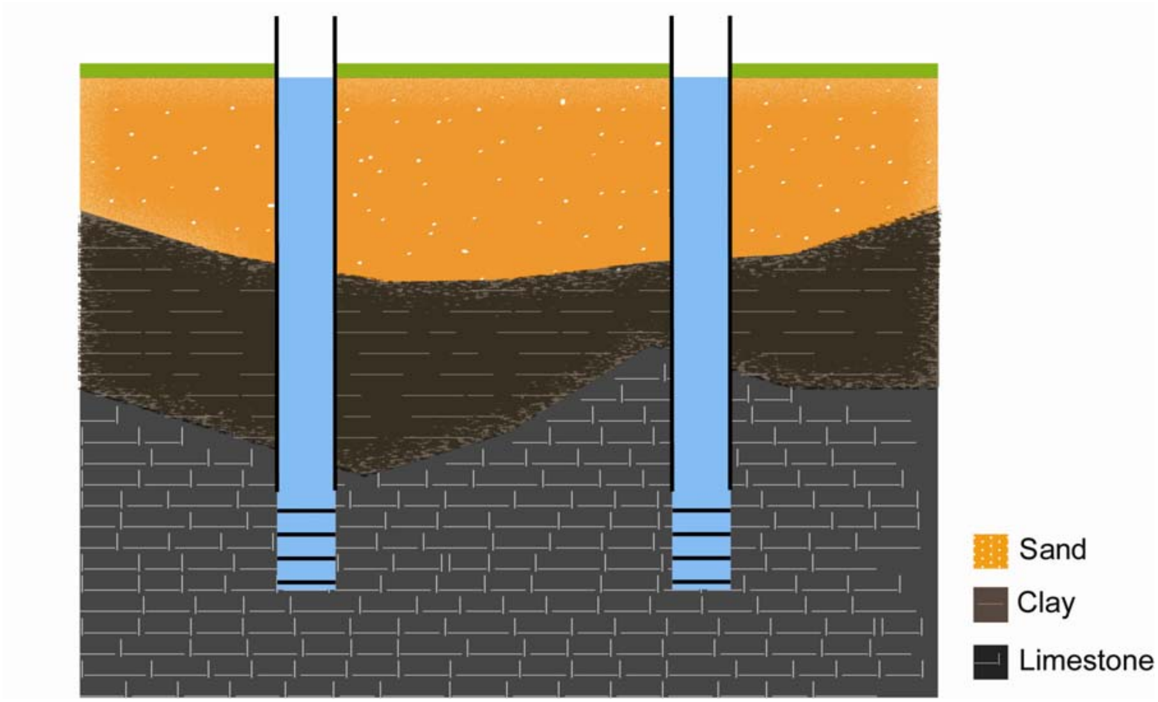
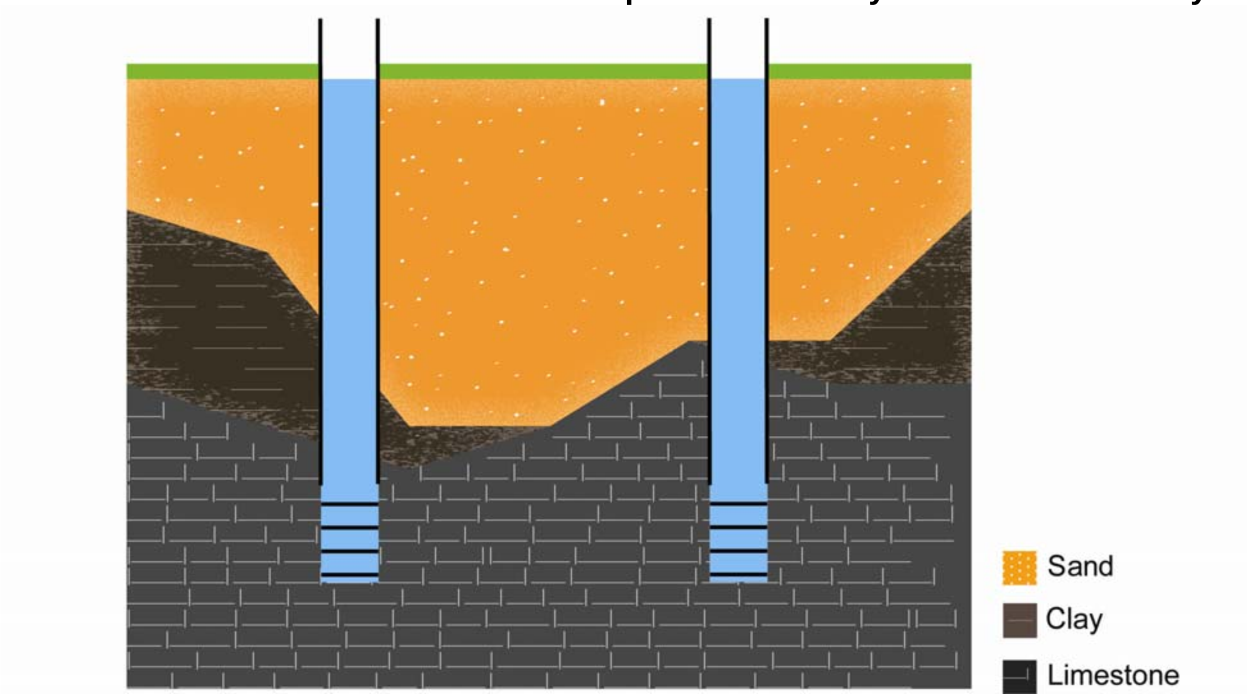


Exhibit 6.5: Wells Screened in a Karst Aquifer Overlain by a Discontinuous Layer



Drillers' logs are often a good way of identifying aquifer type. A driller's log typically records changes in lithology with depth, although local terminology may be used and may need deciphering. For example, in much of the United States the term "artesian well" is used by drillers as a lay term to indicate a producing bedrock well. This contrasts with the hydrogeologist's definition - a confined aquifer where the water in a well rises above the top of the aquifer, sometimes flowing to the land surface. Another example is the use of the term "hardpan" by drillers to describe what may be a dense glacial till, a cemented soil, or a hard clay. A driller's log may also include information on the drilling method employed, which may give clues to the type of materials the drillers encountered.

6.2.2 Additional Data

This section discusses in detail a wide spectrum of data that States and systems may consider useful. Some information may not be readily available to systems. Before expending significant resources to gather additional data, systems should consult with the State or primacy agency and consider the trade-offs for investing so heavily in a pursuit of representative monitoring because they may not need to conduct significant amounts of triggered monitoring. On the other hand, some systems may have one or more of these helpful pieces of information available that can aid them with their representative monitoring analysis and justification.

6.2.2.1 Hydrogeologic Data Sources

A number of EPA publications provide detailed discussions of hydrogeologic data sources. An EPA workgroup was convened in 1993 to develop a guidance document on ground water resource assessment. The guidance describes sources of hydrogeologic data and how this data may be used to evaluate aquifer sensitivity (USEPA 1993a). EPA also published the Ground Water Information Systems Roadmap, A Directory of EPA Systems Containing Ground Water Data (USEPA 1994a). Another reference that summarizes hydrogeologic data sources is an EPA Handbook entitled Ground Water and Wellhead Protection (USEPA 1994b).

State and Federal Hydrogeologic Investigations

These data sources are electronic or hard copy reports or data produced through previous desktop analyses or field investigations. Such information may have been generated to meet the requirements of Source Water Assessment Plans (SWAPs), or through water quality or water supply investigations initiated at the local, State, or federal level. Existing data for a given PWS well may be used. For example, if an existing report or appropriate scale map indicates whether two wells are screened in a particular aquifer, then that information can be used to help determine if the wells should be considered representative of each other. Generally, spatial data at the scale of 1:100,000 or larger (e.g., 1:24,000) are sufficiently detailed for most purposes [Note: large scale maps provide detailed information of small geographic areas.]

Wellhead Protection and Source Water Assessment Studies

The Safe Drinking Water Act (SDWA), as amended in 1986, created the Wellhead Protection Program (WHPP). Each State is required to adopt a program to protect wellhead areas within its jurisdiction from contaminants that may have adverse health effects and to submit the program plan to the EPA Administrator. Currently, 49 States and two territories have

WHPPs in place. In their WHPPs, States address all program elements including how to delineate wellhead protection areas (WHPAs) and how to identify and inventory all potential sources of contamination.

Section 1453 of the 1996 SDWA Amendments required all States to establish SWAPs and to submit plans to EPA for approval by February 6, 1999. These SWAPs address both surface water and ground water protection, and their SWAP plans detail how States will: (1) delineate source water protection areas; (2) inventory significant contaminants in these areas; and (3) determine the susceptibility of each public water supply to contamination. States may use any available information to carry out the SWAP, including data generated through the WHPP. After plan approval, the States must have completed susceptibility determinations for all PWSs by November 6, 2001, unless the State was granted an 18-month extension until May 6, 2003.

EPA encourages States and systems to build upon previous SWAP or WHPP efforts to help determine if two or more wells are representative of one another. A review of selected, approved State SWAP plans across EPA regions indicates that many States intend to evaluate hydrogeologic information that may enable them to determine a PWS well's aquifer type. Data in approved SWAP plans may include the aquifer types in which PWS plans are screened as well as information on the continuity of confining layers (e.g., WIDNR 1999). Other approaches to fulfilling SWAP requirements are also likely to result in data that will be useful for determining representativeness of wells. Case studies # 2 and # 4, presented in sections 3.2.2 and 3.3.2, respectively, of the *Ground Water Rule Source Assessment Guidance Manual*, illustrate just two ways in which data can be extracted from SWAP investigations. This guidance manual is available at
http://www.epa.gov/safewater/disinfection/gwr/pdfs/guide_gwr_sourcewaterassessments.pdf

State Geologic Survey, USGS, and Other Hydrogeologic Investigations

Many State geologic surveys or agencies of natural resources have significant experience studying local and regional aquifer systems and investigating ground water quality and quantity issues. Although many of these studies may have directly supported, or continue to support, SWAP or WHPP work, many more studies have been conducted independent of these efforts. In addition to State geologic surveys, the United States Geological Survey (USGS) has district offices that perform similar work in each State, sometimes in cooperation with State agencies. Universities, local governments, and non-governmental organizations also conduct pertinent hydrogeologic research.

Hydrogeologic and Geologic Maps

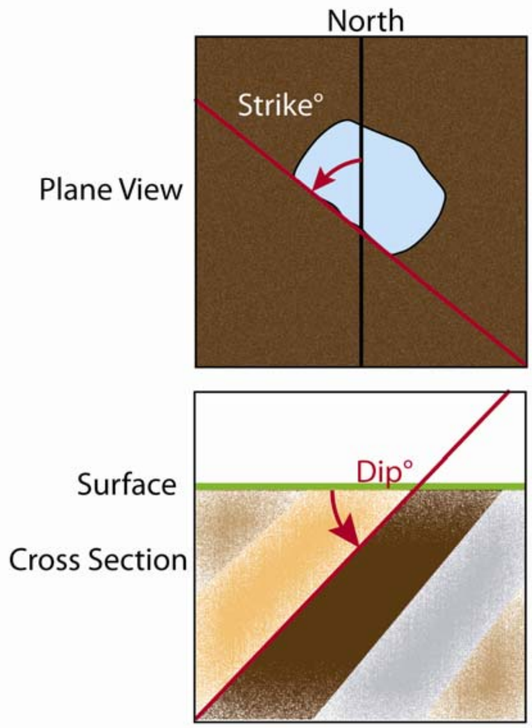
Hydrogeologic or aquifer maps generally show the location, spatial extent, and depth of aquifers in a region. Such maps typically include information on aquifer type as well. Hydrogeologic maps will often be the most direct means to evaluating aquifer type and presence of continuity of confining layers.

Geologic maps may depict a region's surficial geology, which would include the locations and extent of distinct unconsolidated deposits and bedrock units exposed at the earth's surface, or, alternatively, the bedrock geology of an area. Surficial geologic maps are available for many areas from the USGS and often include a key to interpret the results of various test holes shown on the map. Using geologic maps is a less direct means to identifying aquifer type than using hydrogeologic maps, but by using analytical techniques such as projection (described below) and using information such as well depth, these data can help determine aquifer type.

The availability of hydrogeologic maps at an appropriate scale varies among States and among regions. The following sources may be useful to States and systems in obtaining appropriate maps for use in determining representativeness of wells. As part of its Regional Aquifer-System Analysis (RASA) program, the USGS produced a large variety of hydrogeologic maps at various scales. Some of these maps are at scales that may be useful for determining representativeness. The RASA program completed studies of 25 major U.S. aquifer systems in 1995. The Ground Water Atlas of the United States was developed as part of the RASA program, and provides small-scale (i.e., less detailed coverage of large geographic areas) hydrogeologic data for the country both as a printed atlas and as a digital dataset (available on the Internet (accessed 6/30/08) at: http://pubs.usgs.gov/ha/ha730/). The printed atlas has 13 individual chapters that cover specific U.S. regions. The Ground Water Atlas data, however, are compiled at scales that may not be suitable for evaluating representativeness of wells at PWSs (e.g., at the relatively small 1:5,000,000 and 1:2,500,000 scales).

In areas where hydrogeologic maps are not available, it is possible to use a geologic map along with the projection method to determine the aquifer type for a well of a given depth. Projection is a structural geologic technique which can be used to determine aquifer depth, or the depth of any local geologic unit at a well, using the strike and dip of the aquifer as measured at nearby outcrops. Typically, bedding (layering) can be described in terms of its strike and dip. Bedding also occurs but may be indistinct in some sedimentary rocks, in metamorphic rocks called metasediments, and in some igneous rocks such as volcanic flows (e.g., basalts). Outcrop mapping of the bedrock is shown on many geologic maps with the values of the strike and dip of the bedding. The strike is the compass direction or azimuth of the line formed by the intersection of the bed with its horizontal (planar) surface. The dip is the angle in degrees between the bedding and a horizontal surface, measured at right angle to the strike (see Exhibit 6.6). If the bedrock is a known aquifer, the depth to that aquifer can be determined by projecting the dip over the distance to the well location. Using simple trigonometry, the depth to the aquifer is then equal to the tangent of the angle multiplied by the distance. This method can be used in areas of simple geology.

Exhibit 6.6: Strike and Dip



More detailed hydrogeologic and geologic maps are available from a variety of public and private entities. The USGS, as well as State geologic surveys or natural resources agencies, are the most prolific sources. However, coverage is highly variable from State to State. The National Research Council (NRC) estimated in 1988 that less than 20 percent of the United States has been geologically mapped at a scale of 1:24,000 or larger (NRC 1993). In response to this situation, Congress enacted the National Geologic Mapping Act of 1992. This act established the National Cooperative Geologic Mapping Program (NCGMP) to implement expanded geologic mapping efforts through a consortium of geologic mappers. As part of this program, the USGS conducts federal mapping projects through its FEDMAP program; STATEMAP, run by State geological surveys, is a matching-funds grant program; and universities participate in another matching-funds program - EDMAP. The USGS coordinates the NCGMP, which has a long term goal of producing 1:24,000 scale geologic maps for high priority areas of the States, and national coverage at the 1:100,000 scale.

The NCGMP also maintains an exceptionally useful database for locating existing geologic maps produced by a wide variety of entities. The database includes mapping currently in progress through the consortium and is searchable by location, scale, and other parameters. The database, as well as general information on the program, is available on the Internet at http://ngmdb.usgs.gov/. A geologic map index is also available for many States showing boundaries for compiled map projects and references.

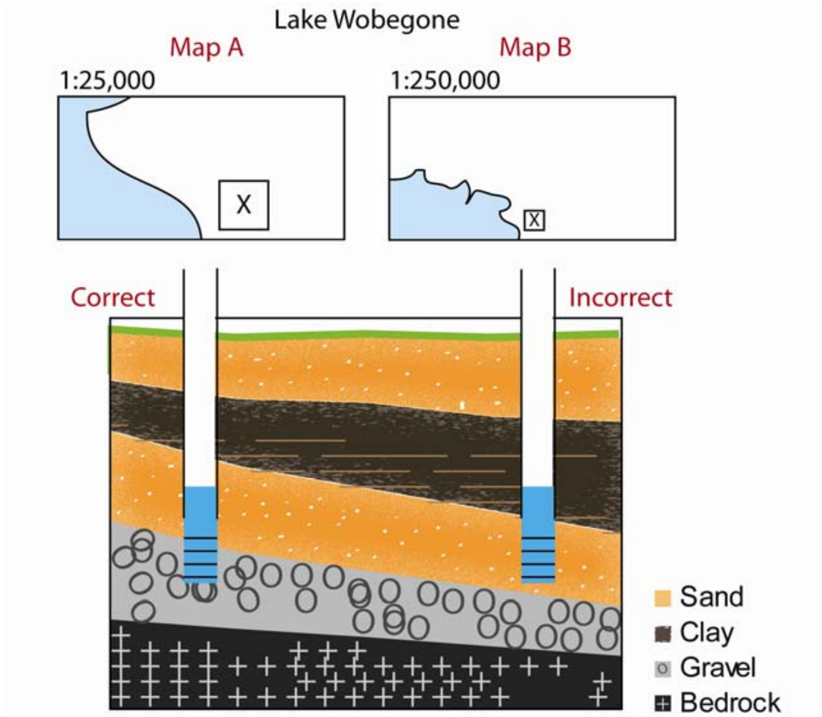
Topographic Data

Well coordinates, depth to the screened interval of a well, and topographic maps (described below) can be used to determine whether particular wells are drawing water from a given aquifer. Imprecise plotting of a well's location could lead to an erroneous assessment of the aquifer type from which the well is drawing water (and thus possibly an incorrect evaluation of whether the well is representative of a nearby well). Accurate determinations of well locations are critical for determining representativeness using a desktop analysis; thus, it is important to use large scale topographic maps (e.g., 1:24,000 topographic quadrangles) for plotting the well's location (see Exhibit 6.7). In the absence of a detailed topographic map (e.g., 1:24,000), a base map of comparable scale is needed to accurately locate the well. Such a map might be available from the local community (e.g., Assessor's Office, Engineering Department, Department of Public Works, Water Board, Board of Health, Planning Board, and Conservation Commission) or from State, federal, or regional natural resource agencies and planning departments.

Accurate well coordinates may be sought first from the PWS's records. Well registration information collected by federal, State, and local regulatory programs also usually include coordinates, or they may be available from the well drilling company records. If necessary, well coordinates can also be obtained in the field using Global Positioning System (GPS) technology.

Exhibit 6.7 below shows the importance of map scale for determining aquifer type. In Exhibit 6.7, X indicates the location of a well with known areal coordinates and depth. Use of the larger scale map, Map A, allows for more precise plotting of the well's location, while use of the smaller scale map, Map B, introduces much more error into the plotting of the well's location. The cross-section shows a correct identification, based on Map A, of the well's aquifer as gravel and an incorrect identification, based on Map B, of the well's aquifer as sand. The exhibit shows how the error introduced by imprecise plotting translates into erroneous determination of aquifer type.

Exhibit 6.7: The Importance of Map Scale for Determining Aquifer Type



Topography can be represented in two dimensions with contours, continuous lines that join points of equal value (equal elevation in this case). The contour interval, which is the change in elevation between each successive contour line (e.g., 20 feet), is chosen depending upon the scale of the map and the topographic relief. The USGS and the Defense Mapping Agency (DMA) have produced most of the topographic maps for the United States (NRC 1993). The USGS produces maps at a variety of scales, but the most common scales for topographic maps are 1:24,000/1:25,000, 1:100,000, and 1:250,000. The 1:250,000 scale maps are available for the entire United States. The much more detailed topographic quadrangles (1:24,000 or 1:25,000) are available for most of the country. Index maps for each State showing available topographic maps are provided by the USGS without charge. Each 1:24,000 topographic map covers approximately 58 square miles, where 1 inch corresponds to 2,000 feet.

Digital topographic data for the United States are also available from the USGS as Digital Line Graphs (DLGs) and Digital Elevation Models (DEMs). DLGs are vector data files that represent linear and areal features commonly found on topographic maps, including contour lines. DEMs are data files that store point elevations spaced at regular intervals in a matrix. Detailed DEMs have 10- and 30- meter resolutions. Because national coverage is incomplete for both DLGs and DEMs, and State-wide coverage varies considerably by State, the remainder of this section will focus on paper topographic quadrangles.

Stereoscopic Aerial Photography

Aerial photographs taken with approximately 30 percent overlap allow three dimensional imaging of land surface features with the aid of stereoscopes. In regions with limited geologic or topographic data, stereoscopic air photos may help locate wells. In most cases, however, such photos will be most useful for determining aquifer types when used in conjunction with other data sources. For example, if low resolution geologic maps or well log data indicate that a given PWS well may be screened in a karst aquifer, stereoscopic air photos could be used to determine the presence or absence of sinkholes or other characteristic karst landform features. Aerial photographs are available from several entities within the USDA and from the USGS.

The NRCS and the Forest Service, both under the USDA, have extensive U.S. coverage at scales appropriate for hydrogeologic sensitivity assessments. The NRCS uses high resolution aerial photography to compile their county level soil surveys at scales ranging from 1:12,000 to 1:63,360. The USDA Aerial Photography Field Office, Farm Service Agency acts as the clearinghouse for all USDA aerial imagery, archiving over 10,000,000 images dating to 1955. USDA aerial photo coverage, availability, and ordering information are available through their Website at: http://www.apfo.usda.gov/.

The USGS National Mapping Division administers the National Aerial Photography Program (NAPP). The NAPP coordinates the collection of cloud-free coverage of the conterminous United States and Hawaii at a uniform scale (approximately 1:40,000) about every five years. NAPP photographs are available in black-and-white, and in many cases, color infrared. The imagery is available from the USGS's Earth Resources Observation Systems (EROS) data center (http://edc.usgs.gov/) or Earth Science Information Centers (ESICs; http://edc.usgs.gov/guides/napp.html). NAPP photos are also available from the USDA Aerial Photography Field Office, Farm Service Agency (see link above).

Well Registration Information, Well Logs, and other Information

Well registration information and well logs collected by local, State, and federal regulatory programs may be very useful for determining aquifer type. Well registrations usually indicate well locations, which is information necessary to determine if wells may be considered representative of one another. A sufficiently detailed driller's log for a PWS well could itself, or in combination with other data sources, adequately characterize the subsurface stratigraphy and aquifer type. For example, based upon a regional bedrock geology map that is of moderately low resolution (e.g., 1:700,000), a State may identify that two PWS wells are located in an area underlain primarily by limestone. The State may review the driller's logs (if available) to confirm that, in fact, the wells are screened in the same limestone aquifer. Certain States such as New Jersey and New Hampshire require drillers to file a log for each well with the appropriate State agency, such as a water well board or the State Environmental Protection Agency.

Additional desktop sources include consultant reports and database searches for property site assessments conducted by private search companies. These searches of federal, State, and local agency databases are conducted as part of due diligence investigations for property site assessments and are usually in accordance with the standards of the American Society of Testing Materials (ASTM). These database searches include a description of the bedrock and surficial geology, a well inventory, and usually air photo coverage for the area in question. The well inventory summarizes well locations, construction, soil and bedrock type, water quality, and other pertinent data.

UCMR 2

Some systems may have already gathered information about their wells to select representative wells under EPA Unregulated Contaminant Monitoring Rule 2 (UCMR 2). This information may help to inform the appropriateness of representative monitoring under GWR.

6.2.3 Capture Zone Models

EPA's Source Assessment Guidance Manual (USEPA, 2008) provides a detailed discussion of capture zone models that are very appropriate for helping to determine whether two or more wells can be considered as possibly representative of one another. Many systems conduct such modeling as part of their wellhead protection efforts. Models in use include Wellhead Protection Area Model (WHPA) and Wellhead Analytic Element Model (WHAEM). Systems and States are encouraged to make full use of information that may be easily available and appropriate in determining representativeness. In cases where capture zone modeling has already been conducted, the results of such modeling likely fall in this category. Where resources permit, EPA recommends that States or systems conduct capture zone modeling for the express purpose of determining whether two or more wells are drawing water from the same areas of the same aquifer, and thus can be considered representative of one another.

References

Barlow, Paul. 1995. *Particle Tracking Analysis of Contributing Areas of Public-Supply Wells in Simple and Complex Flow Systems, Cape Cod, Massachusetts*. United States Geological Survey Water-Supply Paper 2434.

Drever, J., 1988. *The Geochemistry of Natural Waters*. 2nd edition. Prentice Hall, NJ.

Freeze, R.A., and Cherry, J.A., 1979. *Groundwater*. Prentice Hall, NJ.

Güler, C., G.D. Thyne, J.E. McCray, and A.K. Turner, 2002. Evaluation of graphical and multivariate statistical methods for classification of water chemistry data. *Hydrogeology Journal* 10:455-474.

Lee, M., 1998. Hands-on laboratory exercises for an undergraduate hydrogeology course. *Journal of Geoscience Education* 6:433-483.

NRC. 1993. *Ground Water Vulnerability Assessment: Predicting Relative Contamination Potential under Conditions of Uncertainty*. Washington, D.C.: National Academy Press. 204 pp.

Piper, A.M., 1944. A graphic procedure in the geochemical interpretation of water-analyses. *Transactions of the American Geophysical Union* 25:914–923.

Stiff, H.A. Jr., 1951. The interpretation of chemical water analysis by means of patterns. *Journal of Petroleum Technology* 3:15-17.

USGS. 1988. A national look at nitrate contamination of ground water, By Bernard T. Nolan, Barbara C. Ruddy, Kerie J. Hitt, and Dennis R. Helsel. Available on the Internet at http://water.usgs.gov/nawqa/wcp/.

USEPA, 2008. *Ground Water Rule Source Assessment Guidance Manual*, Office of Water, EPA, EPA document 815-R-07-023.

USEPA. 1993a. *Ground Water Resource Assessment*. Office of Water, EPA. EPA Report 813/R-93-003 166 pp and 4 appendices.

USEPA. 1994a. *Ground Water Information Systems Roadmap, A Directory of EPA Systems Containing Ground Water Data*. EPA Report 813-B-94-001.

USEPA. 1994b. *Handbook, Ground Water and Wellhead Protection*. EPA Report 625/R-94/001. 269 pp.

Wisconsin Department of Natural Resources (WIDNR). 1999. *Wisconsin's Source Water Assessment Program Plan*. Available on the Internet at: http://www.dnr.State.wi.us/org/water/dwg/gw/SWP.HTM. Accessed August 20, 2008, last updated November 18, 2004.

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7. Additional Useful Considerations for Representative Monitoring Proposals

The GWR includes flexibility for representative source water monitoring to reduce the burden of sampling ground water sources. Ultimately, each State decides if the specifics of a particular system warrant representative monitoring and whether to require a written triggered source water monitoring plan. As noted in section 1.2 of this manual, the GWR has granted States flexibility on representative monitoring in that it is not an all-or-nothing approval process. That is, not all systems need to participate, and not all sources in a given system warrant representative monitoring.

The GWR is clear in requiring State approval of all representative monitoring – whether it is requested for triggered monitoring or as part of a State-mandated assessment source water monitoring program. The GWR is also specific in requiring that representative monitoring be approved before it can be applied by a system; therefore, a GWS cannot conduct monitoring only at representative sources without prior State approval. When considering representative sampling, EPA encourages water systems to consult the State or primacy agency early to determine if representative sampling is applicable for the system and the level of effort and information that may be needed to ensure equivalent public health protection as that achieved by monitoring all sources or wellheads.

This chapter describes the information EPA recommends States require and/or review prior to approving representative monitoring of ground water wells. All of these items have been discussed previously in this manual; this information is presented here to serve as a checklist of the elements EPA considers essential to making an informed decision. Appendix C summarizes the points included in this chapter.

7.1 Reviewing the Proposal

States are responsible for reviewing requests from water systems to conduct representative source water monitoring. EPA believes that representative source water monitoring can be as protective of public health as monitoring all wellheads, provided that the chosen wells are truly representative of all wellheads.

As they review requests from utilities, States should consider the goal of public health protection by approving representative monitoring only when it is appropriate. This section discusses what information States should consider requesting from systems, and provides guidance on how to evaluate a system's request for representative monitoring.

7.1.1 Technical Considerations when Reviewing Proposals for Representative Monitoring

There are two general reasons why a system would propose conducting representative monitoring: 1) to sample certain ground water sources that represent certain TCR sampling sites in the distribution system (and not sample other ground water sources that do not provide water to the particular TCR sampling site; or 2) to sample one or more wells that represent multiple wells in the same hydrogeologic setting. States may allow a ground water system to address either or both of these circumstances in their proposal to conduct representative monitoring.

Some criteria that States may use during a technical review of both these categories of representative monitoring are provided below.

7.1.2 Ensuring the Proposal is Complete

Systems should consult with the State before submitting proposals to be sure that they are familiar with State expectations. The first step in a State's review may be to ensure that the proposal provided by the system has considered all of the information needed for a complete review. Depending on the nature of the system's request, different materials may be submitted. These may include a written plan (if required by the State), which should include:

For one or more representative sources serving a TCR sampling site:

- Map or schematic of the system. The distribution system map or schematic should not contain information that poses a security risk to the system, but should include the following:
  - Pressure zone boundaries in the distribution system.
  - TCR routine monitoring locations, distinctly labeled.
  - Entry points of all sources, distinctly labeled, with the contributing sources clearly identified.
  - Entry points and status of any interconnections to other systems.
  - Storage tanks / reservoirs.
  - Pressure regulation facilities (reducing stations).
  - Other infrastructure that may affect pressure and/or flow in the distribution system.
  - Booster pump stations.
  - Critical valves.
- The source type and level of treatment provided for each source/point of entry such as whether it is seasonal, emergency, ground water, surface water, a wholesale supply, etc.
- The source(s) serving each TCR compliance monitoring location and the basis for the determination such as system hydraulics, operation, water quality data, etc.

For one or more representative wells in the same hydrogeologic setting:

- Physically and hydrogeologically representative ground water sources that will be used to satisfy the triggered monitoring requirements or State required assessment or additional monitoring requirements of the GWR and the basis for the selection.
- Any changes or variations expected in the triggered source water monitoring plan such as the use of seasonal sources, rotating sources, etc.

The triggered source water monitoring plan can be a stand-alone, independent document or it can incorporate the TCR sample siting plan. In addition, many systems might need to create a multi-scenario triggered source water monitoring plan to reflect the variety of ways their system is operated over the year. The system should not only submit the appropriate supporting study results and other information, but should also include a narrative explaining how the information supports the system's case for representative monitoring.

7.1.2.1 Ground Water Sources Representing Coliform Monitoring Locations in the Distribution System

Groundwater systems have a wide variety of tools available for evaluating the distribution system and determining which sources contribute to each TCR site. Simple water systems with uncomplicated distribution systems should be straightforward to evaluate. For some systems, locating sources, entry points, pressure zones, and TCR sites on the distribution system map may suffice. Systems that are more hydraulically complex will require a more advanced analysis of water movement. Hydraulic models or tracer studies help to inform whether sections of the distribution system are hydraulically separated. To provide maximum public health protection, States should take a conservative approach when considering reducing the number of sources that have to be sampled when source sampling is triggered. Sources that have very little likelihood that water from that well was the cause of the coliform sample may be eliminated from triggered source water monitoring.

Expert judgments will be made by appropriately trained State staff. The following relevant considerations may be helpful to the States as they consider requests from systems. In addition, the considerations may be helpful to systems as they prepare requests for the States:

- Does the system identify each TCR sampling site as well as each source / entry point into the distribution system?
- Does the system demonstrate that areas of the distribution system are consistently hydraulically disconnected due to elevation, pressure gradients, tank locations, or through valving?
- Do historical operating records of the system's wells and distribution system support the system's proposal for representative monitoring?
- Is water flow possible from one zone to another but generally unlikely during normal operating conditions? If so, is this enough to justify representative monitoring?
- Do all sources of information available, including water quality data, match certain wells to certain sampling sites in the distribution system? Does the water quality differ enough among the various distribution system locations to distinguish the sources of water?
- If a distribution system hydraulic model is used:
  - Is the model calibrated?
  - Are demand patterns accurately detailed?
  - Does the model characterize the current hydraulic configuration of the distribution system?

    - Does the model provide a sufficiently detailed view of the distribution system?

7.1.2.2 Wells Representative of Other Wells in the same Hydrogeologic Setting

Determining whether one or more wells are representative of the risk of fecal contamination of multiple wells should be based on a single-elimination approach. That is, if a ground water source fails to meet *any one* of several details, it should be eliminated from further consideration of representative monitoring.

Helpful data or information used to determine if wells should be considered representative of one another includes proximity to other wells, well construction, water chemistry, the aquifer type tapped by the well and the overall hydrogeology of the site. Example sources of information that might be submitted include:

- Well locations plotted using GPS or other means to denote proximity to other wells.
- Well construction details for each well, including depth, grouting, sanitary seal, and screened interval.
- Water chemistry analysis results demonstrating similarities or differences among wells or vulnerabilities of wells to contamination.
- Aquifer information and other hydrogeologic studies, as appropriate. Hydrogeologic studies may include:
    - Wellhead protection or source water assessment studies (may inform location and proximity to potential sources of contamination).
    - State Geologic Survey, USGS, and other hydrogeologic investigations.
    - Hydrogeologic and geologic maps.
    - Topographic data.
    - Stereoscopic aerial photography.
    - Capture zone models.

An important consideration when evaluating whether a system can conduct representative monitoring is the sanitary condition of the wells themselves. Wells being considered for representative monitoring should be structurally sound (e.g., raised casing, sanitary seal) and similar in design to one another. The State should be careful not to approve representative monitoring resulting in a well not being sampled that is in poor sanitary condition. If such a situation were approved, the well that was in poor sanitary condition and not sampled could be a source of fecal contamination that would not be identified under triggered source water monitoring.

While source water chemistry data can be an excellent tool for identifying wells that are representative of each other, States should ensure that water chemistry results submitted are representative of the wells under all operating conditions. Results submitted for TDS, chloride, nitrate, or other chemical parameters should be accompanied by a narrative explaining why the data should be considered representative of the wells under all conditions, and how the water chemistry data collected reflects the spectra of flows and seasonal variability that may impact each well's water quality.

Submittals to the State of hydrogeologic studies should provide information on aquifer type as well as confining layer information. Systems should include in their submittals a narrative that interprets the findings of any submitted hydrogeologic studies in the context of the wells being addressed by the proposed representative monitoring.

The following relevant considerations may be helpful to States as they consider requests from systems. In addition, they may be helpful to systems as they prepare requests for States:

- Is each well's structure and condition sufficiently characterized? Are the structural conditions of the wells being grouped similar?
- Did the system provide third party information about the structure and condition of its wells (e.g., driller's log or well completion report) to support the characterization of the wells?
- Are flows from the wells being addressed similar to one another?
- If a hydrogeologic study is included, does it provide information on the aquifer type and the confining layer?
- If water quality data are included and integral to defining the representative monitoring locations, do the data characterize all wells in use under the full ranges of seasonal and flow conditions?
- If multiple wells are determined to be representative of each other, how many wells will be sampled? Will the sampled wells be alternated?

7.2 Notifying the System and Recordkeeping Associated with a Representative Monitoring Decision

States are required to keep records of approvals of triggered source water monitoring plans (40 CFR 142.14(d)(17)(vi)). These records include all supporting information and an explanation of the technical basis of each decision. This recordkeeping requirement of States is another reason that may compel States to require systems to submit written triggered source water monitoring plans.

States should notify the system with the status of their applications, and GWSs should confirm with their State or primacy agency that they have approval before implementing representative source water monitoring. If the State approves representative monitoring for a system but does not require the system to prepare a written triggered source water monitoring plan, the State may want to include in the written record of its decision the conditions of the approved representative monitoring.

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APPENDIX A

Examples of Five Triggered Source Water Monitoring Plans

- Example 1 – Demonstrates ground water sources representing coliform monitoring locations in the distribution system

- Example 2 – Demonstrates wells representing other wells in the same hydrogeologic setting

- Example 3 – Demonstrates ground water sources representing coliform monitoring locations and wells representing other wells in the same hydrogeologic setting

- Example 4 – Demonstrates a combination system of one wholesale system and one consecutive system

- Example 5 – Demonstrates a system with one SWTR-compliant surface water source, one regularly-used ground water source, and an emergency backup ground water source

EXAMPLE 1

Triggered Source Water Monitoring Plan for Our Town Water System

Ground water sources representing coliform monitoring locations in the distribution system.

A. System Information

(Enter the following information about the water system.)

Water System Name: *Our Town Water System*

PWSID #: *AA7654321*

County or District: *Clark County*

Ground Water Sources:

Source Name	Source ID Number	Well Depth
Well 1	*WL002*	*200 ft*
Well 2	*WL003*	*800 ft*

Storage: *2 hydropneumatic tanks – each 100 gallons*

Treatment: *None*

Booster Stations: *None*

Pressure Reducing Stations: *One*

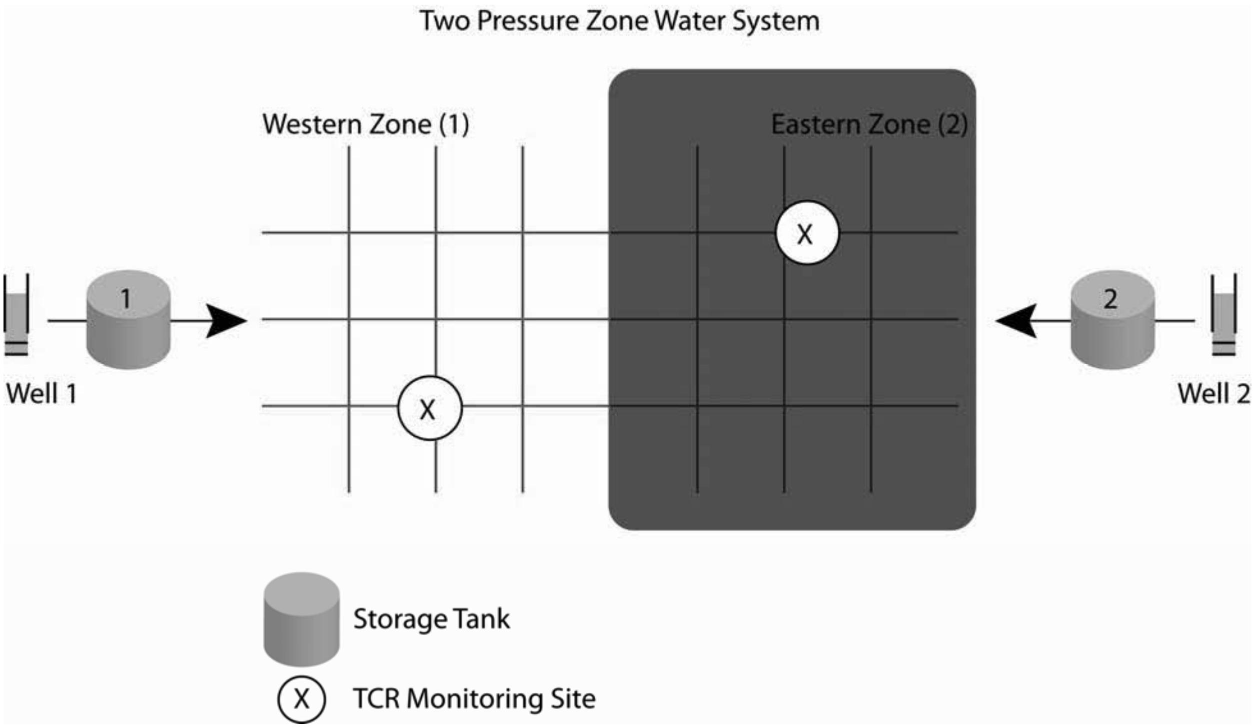
Pressure Zones: *There are 2 pressure zones. Well 1 serves the western pressure zone (zone 1). Well 2 can serve both pressure zones (zones 1 or 2).*

TCR sample sites: *We have two TCR sites. One site is in the western zone (zone 1) and the other is in eastern zone (zone 2). (See map attached).*

Population and Connections by Pressure Zone	Population	Connections
Pressure Zone 1 – Western	*750*	*302*
Pressure Zone 2 – Eastern	*1,085*	*452*
Total Population and Connections Served	*1,835*	*754*

B. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, pressure zones, distribution system, storage tanks, and TCR sites.)



C. Wells Representative of Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	*Our system has two pressure zones. The western zone is at a lower elevation and is generally fed by Well 1 although during high demand, it is also fed by Well 2. The eastern zone is higher and is fed by well 2 only.*
Coliform Monitoring Plan:	*Our plan identifies primary TCR sampling sites as well as upstream and downstream sites that are sampled in the event of a TC+ sample.*
Distribution system hydraulic models:	*Not used.*
Water quality parameters:	*Not used.*
Other:	*Under normal operating conditions Well 1 is sufficient to serve the western pressure zone (zone 1), and Well 2 serves the eastern zone (zone 2). However, during the high demand experienced during summer months (May through September), Well 1 does not have enough capacity to meet the demand in Zone 1. When pressures in zone 1 drop to 35 psi, water is fed from the eastern zone into the western zone through a pressure reducing valve located at a valve vault near the intersection of Main and Elm Streets.*

D. Wells Representative of Each Other

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: *No*

If Yes, list sources and provide justification:

Ground water sources: ____________________

Justification:

E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Seasonal Considerations
1	*Western (Zone 1)*	*Wells 1 & 2*		*Wells 1 & 2*	*Well 2 only serves this site during high demand (when pressures drop below 35 psi). This is typically in the months of May through September*
2	*Eastern (Zone 2)*	*Well 2*		*Well 2*	*n/a*

EXAMPLE 2

Triggered Source Water Monitoring Plan for Lakeview Water System

Wells representing other wells in the same hydrogeologic setting.

A. System Information

(Enter the following information about the water system.)

Water System Name: *Lakeview Water System*

PWSID #: *AA3434343*

County or District: *Trout County*

Ground Water Sources:

Source Name	Source ID Number	Well Depth
Well 1	*WL002*	*250 ft*
Well 2	*WL003*	*250 ft*

Storage: *2 hydropneumatic tanks – each 100 gallons*

Treatment: *None*

Booster Stations: *None*

Pressure Reducing Stations: *None*

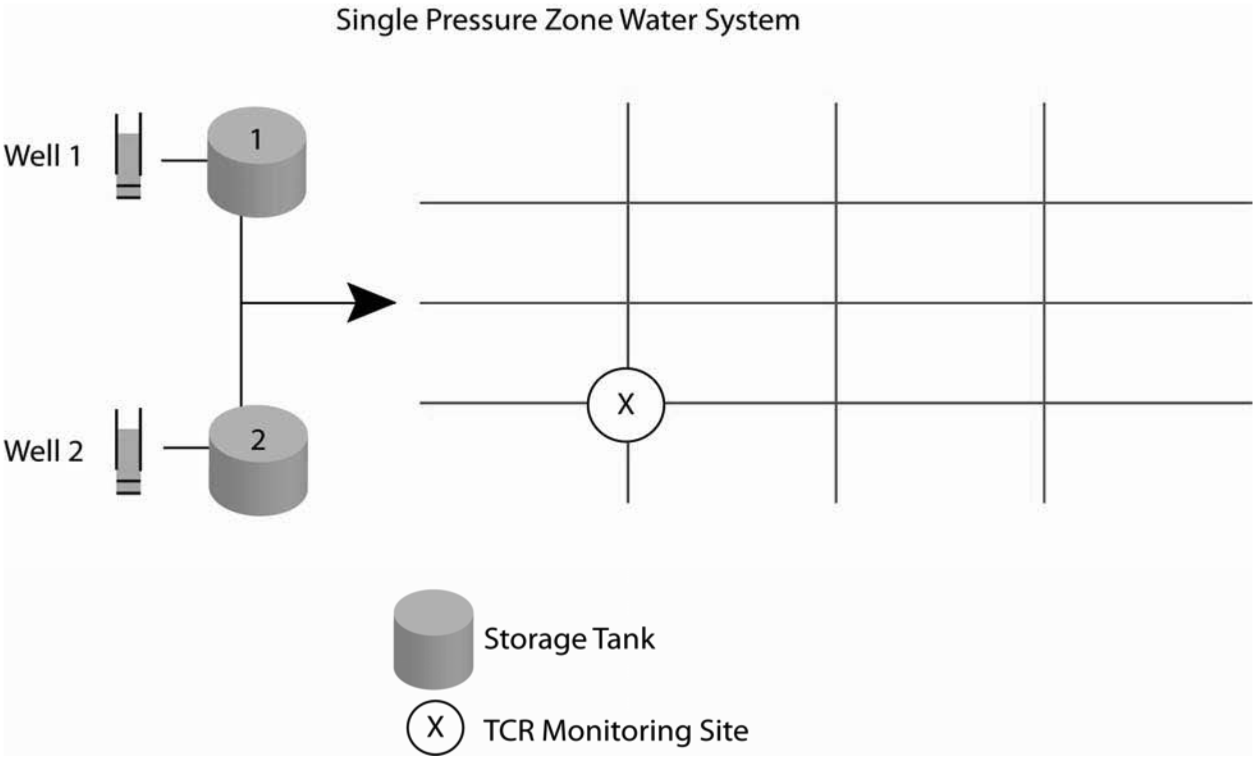
Pressure Zones: *There is a single pressure zone.*

TCR sample sites: *There is one site.*

Population and Connections by Pressure Zone	Population	Connections
Single Pressure Zone	*511*	*204*

B. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, transmission mains and primary distribution mains, pressure zones, distribution system, storage tanks, TCR sites and a scale.)



C. Wells Representative of Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	*Both wells serve the entire distribution system.*
Coliform Monitoring Plan:	*We have 1 TCR site. Both wells contribute to this site.*
Distribution system hydraulic models:	*Not used.*
Water quality parameters:	*Not used.*
Other:	

D. Wells Representative of Each Other

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: *Yes*

If Yes, list sources and provide justification:

Ground water sources: *Wells 1 and 2*

Justification:

The town is served by a small well field of 2 wells, both within a 2 acre site at the west side of town. The attached well logs show that all wells were completed in the same aquifer and drilled to approximately 250 feet. In 2007 our engineering consultant prepared a wellhead protection plan (also attached) which shows that the wells all have a common recharge area which is free of any obvious sources of nearby fecal contamination.

We feel that each of these wells are representative of the water quality drawn from this site, and are therefore appropriate for representative monitoring. If source monitoring is triggered by a TCR positive sample, we propose to sample only 1 of the 2 sources for E. coli.

E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Special Operating Conditions
1	*1*	*Wells 1 & 2*	*Wells 1 & 2*	*Well 1 or 2*	*n/a*

EXAMPLE 3

Triggered Source Water Monitoring Plan for Hydropolis Water System

Ground water sources representing coliform monitoring locations and wells representing other wells in the same hydrogeologic setting.

A. System Information

(Enter the following information about the water system.)

Water System Name: *Hydropolis Water System*

PWSID #: *AA1234567*

County or District: *Beaverhead County*

Ground Water Sources:

Source Name	Source ID Number	Well Depth
Well X	*WL002*	*200 ft*
Well Y	*WL003*	*200 ft*
Well Z	*WL004*	*350 ft*
Well A	*WL005*	*150 ft*
Well B	*WL006*	*800 ft*

Storage: *Two ground level storage tanks – each 50,000 gallons. The Blueberry Tank is located in the Blueberry Hills zone (zone 2). The Hill Tank is located in the Hydropolis zone (zone 3).*

Treatment: *None*

Booster Stations: *None*

Pressure Reducing Stations: *None*

Pressure Zones: *There are 3 pressure zones. Wells X, Y, and Z pump to the Blueberry Tank in zone 2 (Blueberry Hills zone). Well Z is a seasonal well that operates in the summer months only. Wells A and B pump to the Hydropolis Tank in zone 3 (Hydropolis zone). Zone 1 (Montgomery zone) is fed by all of the wells.*

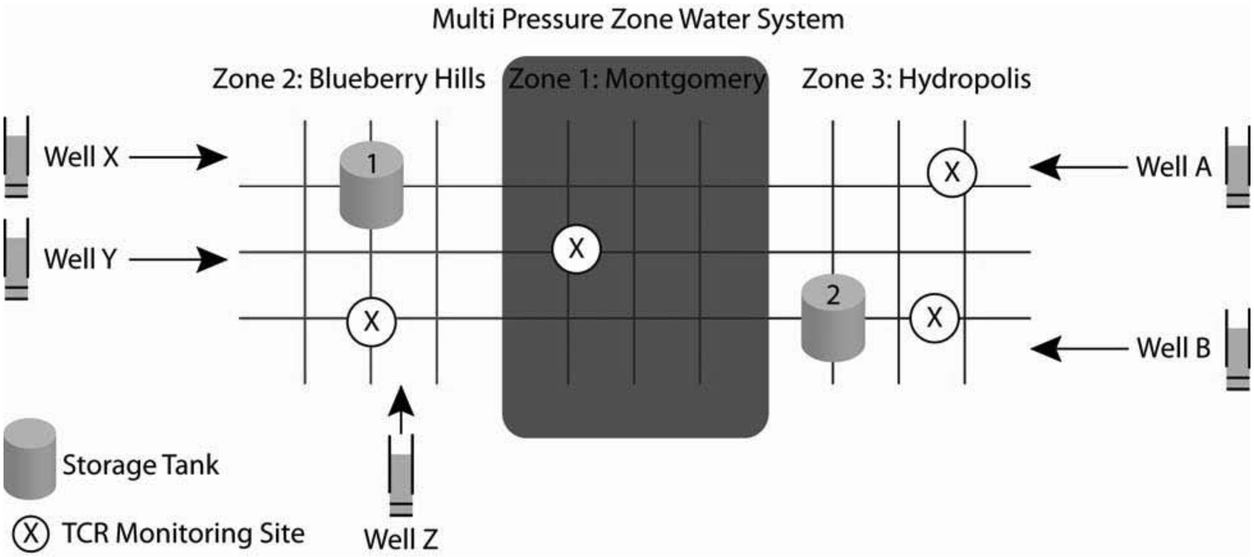
TCR sample sites: *We have four TCR sites. One site is in the Blueberry Hill zone, one site is in Montgomery zone, and two sites are in the Hydropolis zone. (See map attached).*

Population and Connections by Pressure Zone	Population	Connections
Pressure Zone 1 – Montgomery Estates	*980*	*412*

Pressure Zone 2 – Blueberry Hills	*1,200*	*542*
Pressure Zone 3 – Hydropolis	*1,525*	*784*
Total Population and Connections Served	*3,705*	*1,738*

B. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, pressure zones, distribution system, storage tanks, and TCR sites.)



C. Wells Representative of Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	*Zone 1 (Montgomery) is at an elevation of 2000 ft, Zone 2 (Blueberry) is at an elevation of 2500 ft, and Zone 3 (Hydropolis) is at an elevation of 2700 ft.*
Coliform Monitoring Plan:	*Our plan identifies the wells that serve each zone and each TCR site. We made this determination based on our map and a hydraulic model prepared for us by our consultant.*
Distribution system hydraulic models:	*The hydraulic model indicates that Wells X, Y, and Z feed the Blueberry Hills zone. Similarly, Wells A and B, located at the eastern end of town, feed the Hydropolis zone. The lower elevation Montgomery Estates zone is fed by both sets of wells. The model also shows that Hydropolis zone and the Blueberry Hills zone are not hydraulically connected.*
Water quality parameters:	*Not used.*
Other:	

D. Wells Representative of Each Other

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: *Yes*

If Yes, list sources and provide justification:

Ground water sources: *Wells X and Y*

Justification:

The Western well field includes Wells X, Y, and Z. Well Z is our oldest well. It was drilled in 1968 and is only 40 feet deep. This well is only used when required by very high demand. Wells X and Y were drilled in 2004 and 2007. They are approximately 400 feet apart, and each is drilled past the perched aquifer at 40 feet and into the deeper more confined aquifer at 130 feet. The logs show a common lithology for each of these wells, and a comparison of water chemistry shows similar TDS levels and no detects on nitrate or nitrite. In addition, the recharge areas for these two wells overlap considerably, and neither has a potential source of contamination unique to that well.

We believe that Wells X and Y are similar enough both physically and chemically that they can be considered representative of each other. Well Z however is not representative of the other wells at this site and should be sampled if it is in use when a TCR sample is total coliform positive in the Blueberry Hills or Montgomery zones.

E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Seasonal Considerations
1	*Montgomery (Zone 1)*	*Wells X, Y, & Z*	*Wells X & Y*	*Wells X or Y, Z*	*Well Z – operational from May through September*
2	*Blueberry Hills (Zone 2)*	*Wells X, Y, Z, A, & B*	*Wells X & Y*	*Wells X or Y, Z A,& B*	*Well Z – operational from May through September*
3	*Hydropolis (Zone 3)*	*Wells A & B*	*N/A*	*Wells A & B*	*N/A*
4	*Hydropolis (Zone 3)*	*Wells A & B*	*N/A*	*Wells A & B*	*N/A*

EXAMPLE 4

Triggered Source Water Monitoring Plan for Town of Paradise Water System

Demonstrates a combination system of one wholesale system and one consecutive system.

A. System Information

(Enter the following information about the water system.)

Water System Name: *Town of Paradise Water System*

PWSID #: *AA1207992*

County or District: *Jefferson County*

Ground Water Sources:

Source Name	ID Number	Well Depth
Paradise Well	*WL001*	*410 ft*
Village of Paradise	*PWS ID AA1209851*	*2 wells*

Storage: *One 80,000-gallon elevated storage tank*

Treatment: *No treatment on WL001. Village of Paradise water is treated with potassium permanganate and green sand filtration for manganese removal.*

Booster Stations: *None*

Pressure Reducing Stations: *None*

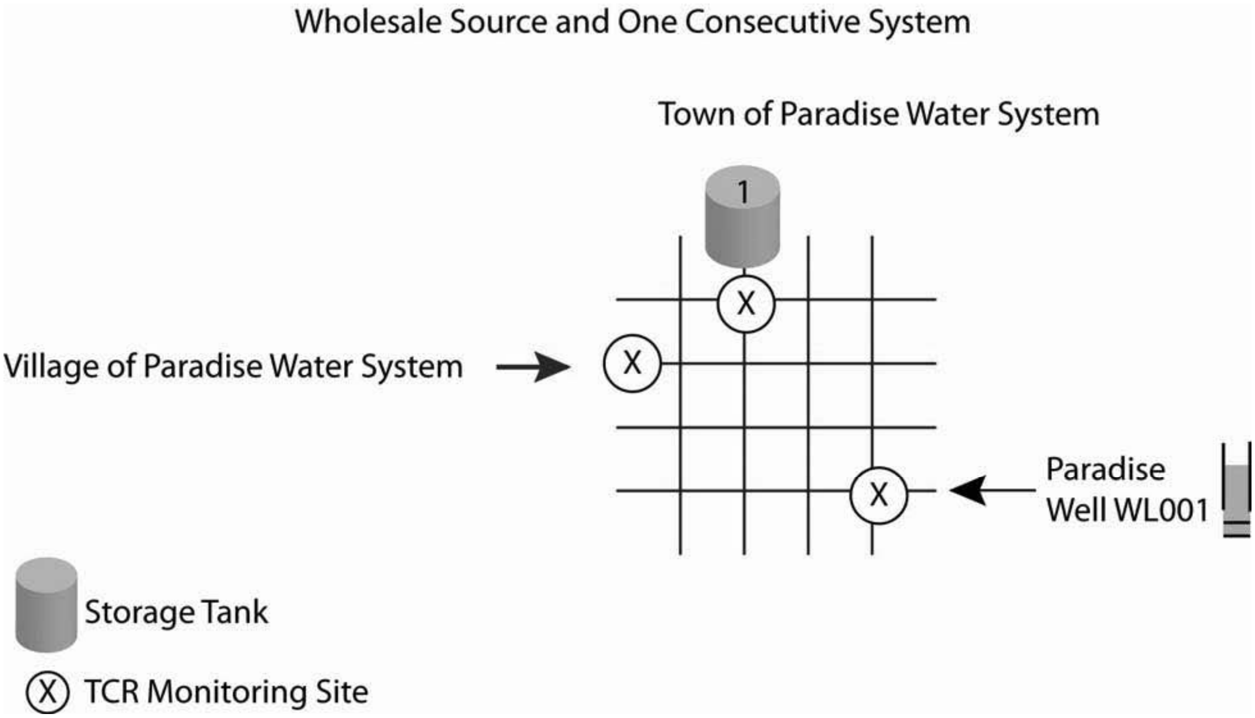
Pressure Zones: *There is a single pressure zone.*

TCR sample sites: *There are three coliform sampling locations.*

Population and Connections by Pressure Zone	Population	Connections
Single Pressure Zone	*2,630*	*957*

B. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, transmission mains and primary distribution mains, pressure zones, distribution system, storage tanks, TCR sites and a scale.)



C. Wells Representative of Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	*Most of the distribution system is served by Village of Paradise Water. On average, we purchase 500,000 gpd from the Village and we pump approximately 30,000 gpd from our own WL001. Since the amount of water entering the distribution system from WL001 is small compared to the amount entering from our connection with the Village, water from WL001 does not reach all parts of the distribution system.*
Coliform Monitoring Plan:	*We have 3 TCR sampling sites: Sample Site 1 is located near the entry point where the Village of Paradise water enters the distribution system; Sample Site 2 is located downstream of the storage tank; and Sample Site 3 is located near the entry point where WL001 water enters the distribution system.*
Distribution system hydraulic models:	*Not used.*
Water quality parameters:	*Not used.*
Other:	*Pressure readings in the distribution system.*
Justification:	*Based on pressure readings at different locations in our distribution system, we know that our storage tank is filled only by the Village of Paradise's water, and service connections upstream of the storage tank*

(between the point where Village of Paradise water enters our distribution system and the storage tank) are also served only by Village of Paradise water. Sample Site 1 was established at its location with the intention that it would represent Village of Paradise water. Sample Site 3 is intended to test water from WL001; again, we picked the sample site location because we wanted to have a sample we knew was representing WL001 water. We can also support this with pressure readings. The source of water at Sample Site 2 is less clear and where the water at that location comes from

depends on the demand in the system at that time.

D. Wells Representative of Each Other

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: *No*

If Yes, list sources and provide justification:

Ground water sources:

Justification:

E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Seasonal Considerations
1	*N/A*	*V. Paradise*	*N/A*	*Notify V. of Paradise*	*N/A*
2	*N/A*	*V. Paradise AND WL001*	*N/A*	*WL001 and Notify V. of Paradise*	*N/A*
3	*N/A*	*WL001*	*N/A*	*WL001*	*N/A*

EXAMPLE 5

Triggered Source Water Monitoring Plan for the Valley View Water System

A representation of a system with one SWTR-compliant surface water source, one regularly-used ground water source, and an emergency backup ground water source.

A. System Information

(Enter the following information about the water system.)

Water System Name: *Valley View Water System*

PWSID #: *AA7654321*

County or District: *Greene County*

Ground Water Sources:

Source Name	Source ID Number	Well Depth
Valley View Well	*WL001*	*125 ft*
Emergency Well	*WL002*	*65 ft*

Storage: *We have one 200,000-gallon ground level storage tank located adjacent to our upland reservoir and its treatment plant. The storage tank only contains treated surface water and feeds the distribution system by gravity flow.*

Treatment: *None (for ground water); Surface water receives conventional treatment.*

Booster Stations: *None but chlorine is injected into water leaving the storage tank.*

Pressure Reducing Stations: *None*

Pressure Zones: *There is one pressure zone. High pressure water flows from the storage tank, but it does not maintain enough pressure to safely supply the easternmost part of the system. Our well (WL001) in the valley provides approximately 12,000 gpd to the eastern part of the distribution system.*

TCR sample sites: *2 coliform samples are collected each month: Sample Site 1 is located in the northwest quadrant of the distribution system, which is served exclusively by water leaving the storage tank; Sample Site 2 is located in the northeastern corner of the distribution system where we* *have had some issues maintaining sufficient pressure.*

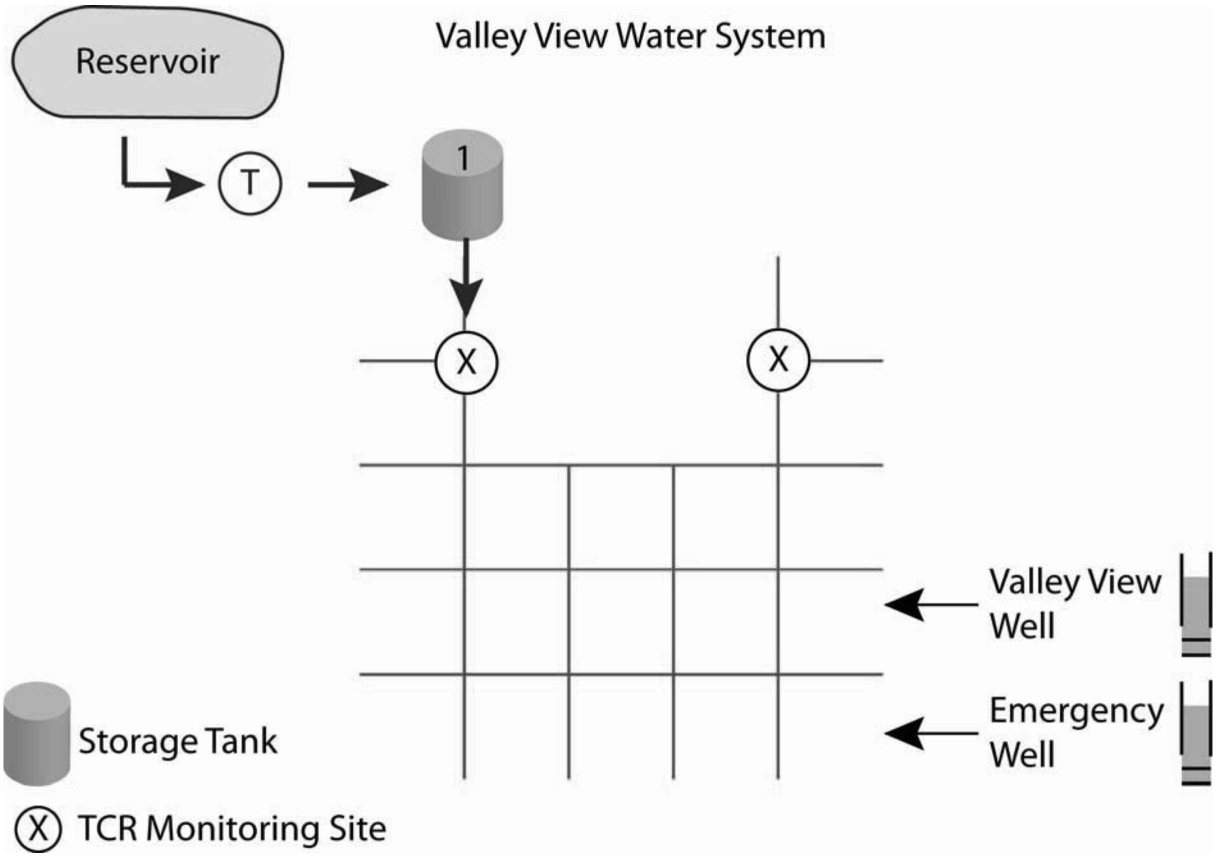
Sample Site 2 receives water from both the surface

water treatment plant and the well.

Population and Connections	**Population**	**Connections**
Valley View Water System	*2,420*	*980*

B. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, pressure zones, distribution system, storage tanks, and TCR sites.)



C. Wells Representative of Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	*The attached distribution system map shows the locations of the coliform sampling sites relative to our water sources and storage tank.*
Coliform Monitoring Plan:	*Not used*
Distribution system hydraulic models:	*Not used.*
Water quality parameters:	*Chlorine residual, pressure*
Justification:	*The free chlorine residual in the water entering the distribution system from the storage tank is maintained at 1.0 mg/L +/- 0.2 mg/L. Based on daily measurements at the Department of Public Works building, where Sample Site 1 coliform samples are collected, the chlorine residual consistently measures at or near 0.8 mg/L. Water at the location where Sample Site 2 coliform samples are collected only has a detectable residual (about 0.1-0.2 mg/L). The higher pressure and higher chlorine residual at Sample Site 1, as well as its location near the storage tank entry point, demonstrate that water at the Sample Site 1 location is provided by the surface water source and not the ground water source.*

D. Wells Representative of Each Other

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: *No*

If Yes, list sources and provide justification:

Ground water sources: *Valley View Well and Emergency Backup Well*

Justification:

The emergency backup well is located within 500 ft. of the Valley View Well. It is turned on for less than one week a year while we are doing maintenance work on the Valley View Well. The emergency backup well is a much shallower well and its water quality is different. If the emergency backup well is in service at the time of a positive coliform result at Sample Site 2, we will sample both the emergency backup well and the Valley View Well.

E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Special Operating Considerations
1	*N/A*	*Valley View Reservoir*	*N/A*	*None*	*N/A*
2	*N/A*	*Valley View Reservoir, Valley View Well, Emergency Backup Well (if in service)*	*N/A*	*Valley View Well, Emergency Backup Well (if in service)*	*Will only sample Emergency Backup Well if it was in service at the time of the coliform-positive result.*

APPENDIX B

Example Triggered Source Water Monitoring Plan (Template)

A. System Information

(Enter the following information about the water system.)

Water System Name: ______________________________

PWSID #: ______________________________

County or District: ______________________________

Ground Water Sources:	**Source Name**	**Source ID Number**	**Well Depth**

Storage: ______________________________

Treatment: ______________________________

Booster Stations: ______________________________

Pressure Reducing Stations: ______________________________

Pressure Zones: ______________________________

TCR sample sites: ______________________________

Population and Connections by Pressure Zone	**Population**	**Connections**

B. Identification of Which Wells Contribute to Each TCR Site

(Provide the following information on the system's TCR sites and how it was determined which source provides the water to that site.)

Tools used to identify wells that contribute to TCR sites	Explanation of how tool was used for identification
Distribution system maps:	
Coliform Monitoring Plan:	______________________________
Distribution system hydraulic models:	______________________________
Water quality parameters:	______________________________
Other:	______________________________

C. Map of the Water System

(Provide a map either below or attached that shows the location of the sources, pressure zones, distribution system, storage tanks, and TCR sites.)

D. Representative Ground Water Sources

(Provide information about sources and justification for representativeness.)

Are there ground water sources in your system that can be representative of each other: ______________________

If Yes, list sources and provide justification:

Ground water sources: ______________________________________

Justification:

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E. Representative Triggered Monitoring Plan

(Complete the following information to indicate the ground water sources to be sampled based on a routine total coliform positive sample taken at a TCR site. Attach additional sheets if necessary.)

TCR Site	Zone	Sources Contributing to this TCR Site	Contributing Sources Representative of Each Other	Representative Source to Sample (Triggered)	Seasonal Considerations

APPENDIX C - Summary of Considerations for Representative Monitoring

There are two general reasons why a system would propose conducting representative monitoring: 1) to sample certain ground water sources that represent certain TCR sampling sites in the distribution system (and not sample other ground water sources that do not provide water to the particular TCR sampling site; or 2) to sample one or more wells that represent multiple wells in the same hydrogeologic setting. States may allow a ground water system to address either or both of these circumstances in their proposal to conduct representative monitoring. A summary of considerations that systems and States may find helpful during development and review of representative monitoring, respectively, are provided below.

For Ground Water Sources Representing Coliform Monitoring Locations

- Ground Map or schematic of the system
- Identification of each source/entry point, its type (e.g., seasonal, emergency), and its level of treatment, if any
- Identification of each TCR monitoring location
- Data correlating TCR monitoring locations to particular ground water source(s) (e.g., hydraulic, operational, water quality, etc.)
- The following relevant considerations may be helpful to States as they consider requests from systems. In addition, they may be helpful to systems as they prepare requests for States:
    - Does the system demonstrate that areas of the distribution system are consistently hydraulically disconnected due to elevation, pressure gradients, tank locations, or through valving?
    - Do historical operating records of the system's wells and distribution system support the system's proposal for representative monitoring?
    - Is water flow possible from one zone to another but generally unlikely during normal operating conditions? If so, is this enough to justify representative monitoring?
    - Do all sources of information available, including water quality data, match certain wells to certain sampling sites in the distribution system? Does the water quality differ enough among the various distribution system locations to distinguish the sources of water?
    - If a distribution system hydraulic model is used:
        - Is the model calibrated?
        - Are demand patterns accurately detailed?
        - Does the model characterize the current hydraulic configuration of the distribution system?
    - Does the model provide a sufficiently detailed view of the distribution system?

For Wells Representing Other Wells in the Same Hydrogeologic Setting

- Well locations plotted using GPS or other means to denote proximity to other wells
- Well construction details for each well, including depth, grouting, sanitary seal, and screened interval
- Water chemistry analysis results demonstrating similarities or differences among wells or vulnerability of wells to contamination
- Aquifer information and other hydrogeologic studies, as appropriate
- The following relevant considerations may be helpful to States as they consider requests from systems. In addition, they may be helpful to systems as they prepare requests for States:
    - Is each well's structure and condition sufficiently characterized? Are the structural conditions of the wells being grouped similar?
    - Did the system provide third party information about the structure and condition of its wells (e.g., driller's log or well completion report) to support the characterization of the wells?
    - Are flows from the wells being addressed similar to one another?
    - If a hydrogeologic study is included, does it provide information on the aquifer type and the confining layer?
    - If water quality data are included and integral to defining the representative monitoring locations, do the data characterize all wells in use under the full ranges of seasonal and flow conditions?
    - If multiple wells are determined to be representative of each other, how many wells will be sampled? Will the sampled wells be alternated?

This appendix provides a summary of major points discussed in the *Ground Water Rule Triggered and Representative Source Water Monitoring Guidance Manual*. Please consult the full guidance for a more complete discussion on each major point. The guidance is available electronically at http://www.epa.gov/safewater/disinfection/gwr/compliancehelp.html.