United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

Interim Final - December 2003

Overview and Application

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 18 2003

OFFICE OF
WATER

Dear Colleague,

I am writing to announce the release of the interim final *Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents* (the *Response Protocol Toolbox*). The *Response Protocol Toolbox* was produced by EPA, building on the experience and expertise of several drinking water utilities, in particular, the Metropolitan Water District of Southern California. Our objective in providing this interim final guidance is to help the water sector effectively and appropriately plan for and respond to contamination threats and incidents.

The *Response Protocol Toolbox* will be of value to drinking water utilities, laboratories, emergency responders, state drinking water programs, technical assistance providers, and public health and law enforcement officials. While the *Response Protocol Toolbox* provides useful direction, it is primarily a planning tool. EPA recommends that users practice implementing this proposed framework and carry-out drills and training to improve preparedness. This draft release includes Modules 1 through 4, as well as an overview of the entire *Response Protocol Toolbox*. Users are encouraged to read the overview before using other Modules. Please note that Modules 5 and 6 will be included in the final release, due in spring 2004. The titles of the Modules are as follows:

- *Overview of the Response Protocol Toolbox* (EPA-817-D-03-007)
- *Water Utility Planning Guide* - Module 1 (EPA-817-D-03-001)
- *Contamination Threat Management Guide* - Module 2 (EPA-817-D-03-002)
- *Site Characterization and Sampling Guide* - Module 3 (EPA-817-D-03-003)
- *Analytical Guide* - Module 4 (EPA-817-D-03-004)
- *Public Health Response Guide* - Module 5 (EPA-817-D-03-005) *under development*
- *Remediation and Recovery Guide* - Module 6 (EPA-817-D-03-006) *under development*

The *Response Protocol Toolbox* modules can be found in electronic PDF format on the EPA website at: http://www.epa.gov/safewater/security/ under *Emergency Response Tools*. Printed copies, in limited quantity, can be obtained from the Water Resource Center by phone: 800-832-7828 or 202-566-1729, by fax: 202-566-1736, or by e-mail: center.water-resource@epa.gov. If additional information is needed, please call the Safe Drinking Water Hotline at 1-800-426-4791.

I ask for your assistance in publicizing the availability of the *Response Protocol Toolbox* to ensure that it reaches the drinking water systems, government officials, laboratories, and first responders who will benefit from it most.

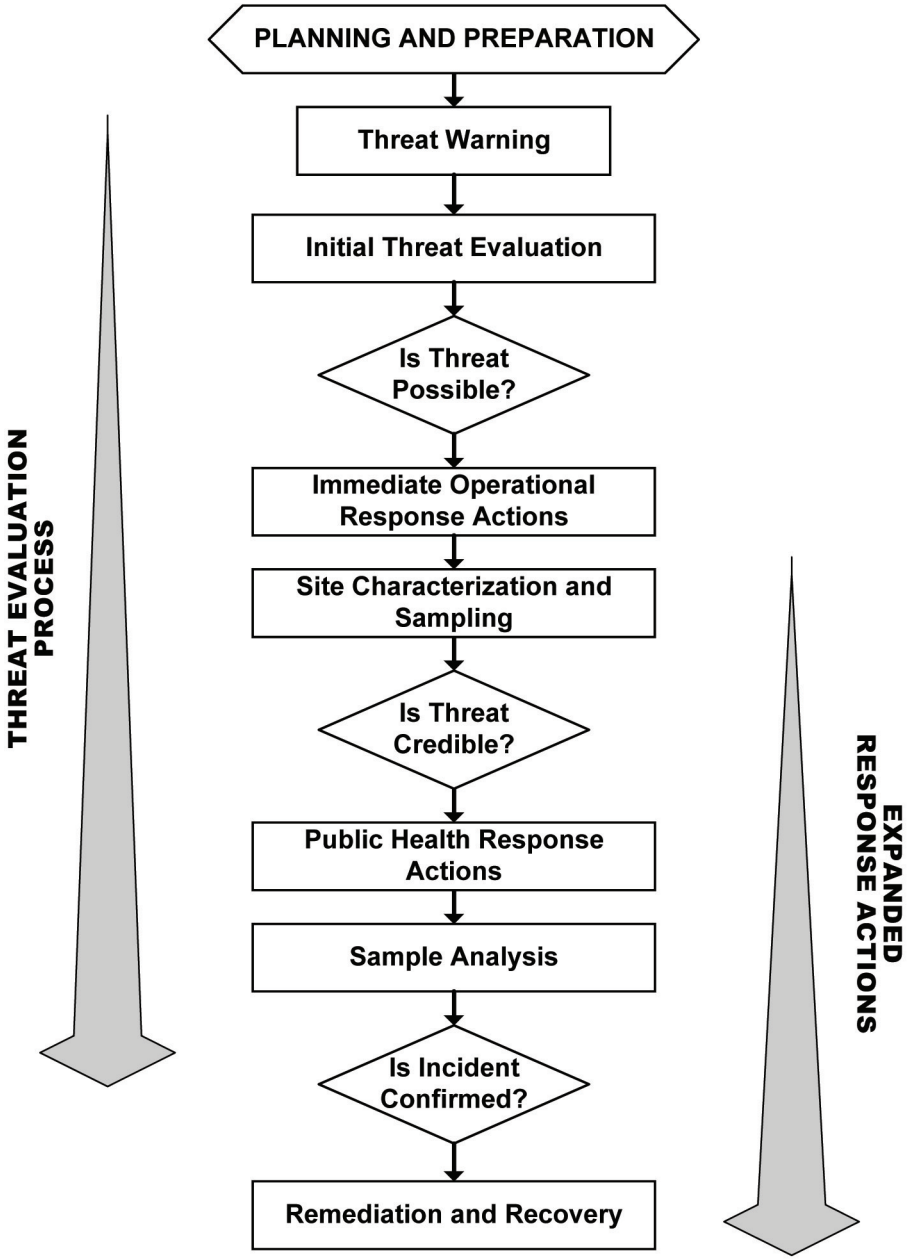
Sincerely,

Cynthia C. Dougherty, Director
Office of Ground Water and Drinking Water

Response Protocol Toolbox:
Planning for and Responding to Drinking Water Contamination Threats and Incidents

Overview and Application

Interm Final - December 2003



ACKNOWLEDGEMENTS

Primary Authors

Steven C. Allgeier, U.S. EPA – OGWDW – WSD
Bart Koch, MWD Southern California
Matthew L. Magnuson, U.S. EPA-ORD-NRMRL-WSWRD
Ricardo DeLeon, MWD Southern California

Utility Workgroup

Ron Hunsinger, East Bay MUD
Cliff Bowen, California DHS
Andy DeGraca, San Francisco PUC
Walter Grayman, Grayman Associates
Bart Koch, MWD Southern California
Ed Means, McGuire Consulting
Melinda Rho, Los Angeles DWP
Mic Stewart, MWD Southern California
Kelvin Yamada, California DHS
Manoucher Boozarpoor, San Francisco PUC
Phillippe Daniel, CDM
Ricardo DeLeon, MWD Southern California
Jack Jacobs, EMA Inc.
Razmik Manoukian, Los Angeles DWP
Pankaj Parekh, Los Angeles DWP
Raymond Riordan, Riordan Associates
Trish Wathen, California DHS

Additional Support

Bob Barles, U.S. EPA – OGWDW
Kim Fox, U.S. EPA – ORD – NHSRC
Jonathan Herrmann, U.S. EPA – ORD – NHSRC
Dennis Juranek, CDC
Nelson Mix, U.S. EPA – OSWER
Janet Pawlukiewicz, U.S. EPA – OGWDW – WSD
Grace Robiou, U.S. EPA – OGWDW – WSD
Diane Van DeHei, AMWA
Susan Dolgin, U.S. EPA – OGWDW – WSD
Brian Frazer, U.S. EPA – OGWDW – WSD
Vince Hill, CDC
Alan Lindquist, U.S. EPA – ORD – NHSRC
Bridget O'Grady, ASDWA
Alan Roberson, AWWA
Tom Schaeffer, AMWA

Technical Reviewers

Phillip Adams, New Mexico Department of Health
Andrew Bielanski, U.S. EPA – OGWDW – WSD
Timothy Croley, Virginia State Laboratory
David Degenhardt, Wisconsin State Lab of Hygiene
Christina Egan, State of New York Dept. of Health
Ed George, Environmental Health Labs
Greg Grover, U.S. EPA – Region 6
Dan Hickman, Oregon DEQ Laboratory
Janet Jensen, U.S. Army - SBCCOM
Marcis Kempe, Massachusetts WRA
Carrie Lewis, Milwaukee Water Works
Denise MacMillan, Army Corp of Engineers
Robert Maxfield, U.S. EPA – Region 1
Anand Mudambi, U.S. EPA – OSWER
Trikam Patel, New York City DEP
Kusum Perera, California DHS
Steve Rhode, Massachusetts WRA
Dave Siburg, Kitsap Public Utility District
Stanley States, Pittsburgh Water & Sewer Authority
Marty Swickard, U.S. EPA – Region 8
Caroline Wehling, U.S. EPA – OGC
Caryn Wojtowicz, Ecology and Environment Inc.
Joseph Barbera, George Washington University
R. Broxter, Kansas Dept. or Health and Environment
Rick Danielson, BioVir Laboratories
Jane Downing, U.S. EPA – Region 1
Michael Eldert, Hampton Roads Sanitation District
John Griggs, U.S. EPA – ORIA
David Hartman, Cincinnati Water Works
Charlie Hooper, U.S. EPA – Region 4
Michael Johnson, U.S. EPA – OSWER
Ewa King, Rhode Island Public Health
Ted Lyter, Pennsylvania DEP
Brad Mahanes, U.S. EPA – OECA – OCEFT – CID
Maureen McClelland, U.S. EPA – Region 1
Julianne Nassif, Massachusetts Dept. of Public Health
Jim Pearson, Virginia State Laboratory
Frances Pouch Downes, Michigan DCH
Paul Servizio, Massachusetts Dept. of Public Health
Drew Smith, Monroe County Environmental Lab
Paul Swedenborg, Minnesota Department of Health
Gene Taylor, U.S. EPA – Region 10
Michael Wichman, University of Iowa Hygienic Lab
Marvin Young, U.S. EPA – Region 9

The Response Protocol Toolbox has been reviewed by U.S. EPA Office of Water, Office of Research and Development, and Office of General Counsel, and approved for release as non-binding guidance.

TABLE OF CONTENTS

1 INTRODUCTION....4

2 OVERVIEW OF THE RESPONSE PROTOCOL TOOLBOX....5

2.1 MODULE 1, WATER UTILITY PLANNING GUIDE....5
2.2 MODULE 2, CONTAMINATION THREAT MANAGEMENT GUIDE....5
2.3 MODULE 3, SITE CHARACTERIZATION AND SAMPLING GUIDE....6
2.4 MODULE 4, ANALYTICAL GUIDE....7
2.5 MODULE 5, PUBLIC HEALTH RESPONSE GUIDE (IN PREPARATION)....8
2.6 MODULE 6, REMEDIATION AND RECOVERY GUIDE (IN PREPARATION)....9

3 APPLICATION OF THE RESPONSE PROTOCOL TOOLBOX....11

3.1 PLANNING A RESPONSE TO A CONTAMINATION THREAT....11
3.2 REVISING "EMERGENCY RESPONSE PLANS"....12
3.3 DEVELOPING "RESPONSE GUIDELINES"....13
3.4 OTHER APPLICATIONS OF THE RPTB....13

LIST OF FIGURES

FIGURE O-1: RELATIONSHIPS AMONG THE MODULES IN THE RESPONSE PROTOCOL TOOLBOX (RPTB)....4
FIGURE O-2: EXAMPLES OF THE USE OF THE RESPONSE PROTOCOL TOOLBOX (RPTB) BY VARIOUS INTEREST GROUPS....12

1 Introduction

The Response Protocol Tool Box (RPTB) is composed of six interrelated modules, in addition to this overview, which focus on different aspects of **planning** a response to contamination threats and incidents, long **before** they occur. The RPTB is primarily concerned with drinking water contamination threats, whereas physical and cyber attacks are mostly related to other security issues and are the subject of documents being prepared separately. Figure O-1 illustrates the interconnected relationships among the modules. Module 1 is an overarching document that serves both as a primer on contamination threats to drinking water systems and an overall guide to utility planning for such incidents. As depicted in Figure O-1, Module 2 is the hub of the toolbox in that it addresses the overall management of a contamination threat. The remaining modules support Module 2 by presenting information and protocols for investigating the contamination threat or implementing actions in response to a contamination threat or incident. The current overview describes the entire RPTB and provides guidance on its application.

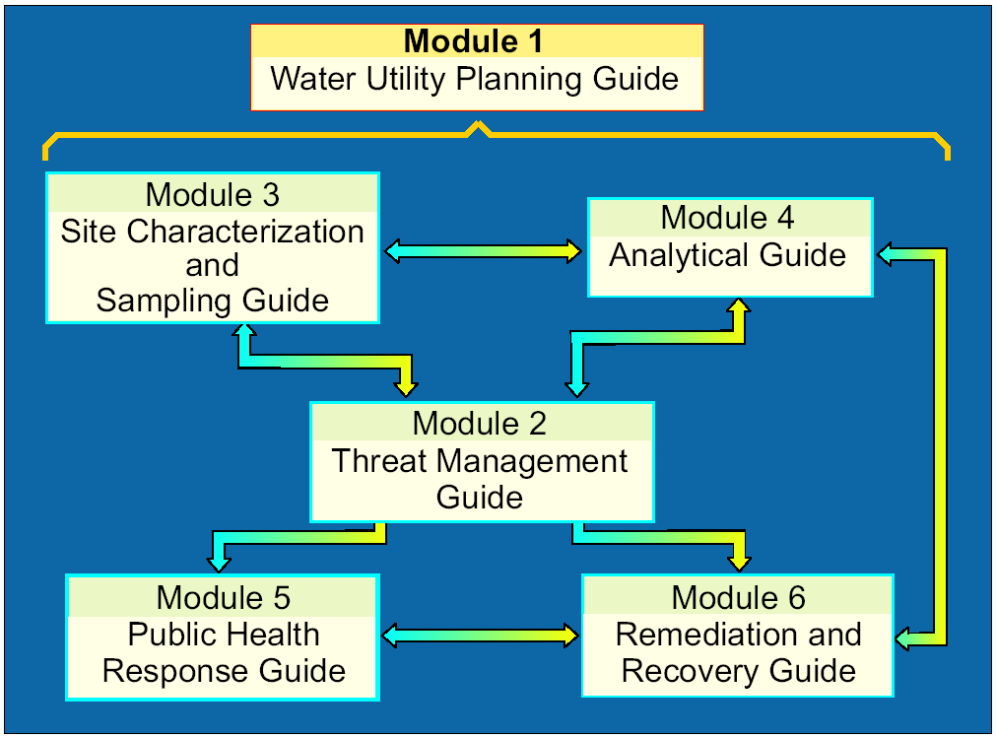


Figure O-1. Relationships among the Modules in the Response Protocol Toolbox (RPTB).

The RPTB is a planning tool, and should be integrated into a user's specific emergency response planning activities in order to effectively manage an actual threat. The modules in the RPTB were **not** prepared for use during the response to an emergency. **Response Guides are intended for that purpose** and are described below in Section 3.3. Furthermore, the RPTB does not implement any specific statutory directive and does not establish any requirements. It is provided as guidance to aid utilities and other users in planning a response to contamination threats.

2 Overview of the Response Protocol Toolbox

The six modules that constitute the RPTB are:

1. Water Utility Planning Guide
2. Contamination Threat Management Guide
3. Site Characterization and Sampling Guide
4. Analytical Guide
5. Public Health Response Guide
6. Remediation and Recovery Guide

This section provides an overview, presents the objectives, and describes the intended audience for each of these modules. While various modules were developed with a specific target audience in mind, any user may benefit from review of all the modules in the RPTB in order to become familiar with the various aspects of the response to a drinking water contamination threat or incident.

2.1 Module 1, Water Utility Planning Guide

Overview. Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to effectively manage contamination threats and incidents.

Objectives. The objectives of Module 1 are to:

1) Familiarize the reader with the nature of water contamination threats and incidents.
2) Provide an understanding of the various planning activities associated with the management of water contamination threat or incident.

Audience. While the planning aspects of this module are targeted at drinking water utilities, much of the information provided will be of interest to any user that might support a drinking water utility during response to a contamination threat. This extended audience might include drinking water primacy agencies, law enforcement agencies, public health agencies, or crisis management organizations.

Highlights. Module 1:

- Provides an overview of contamination threats.
- Describes the various warning signs of a potential contamination incident.
- Discusses the concept of "due diligence" in responding to contamination threats.
- Lists several areas where planning and preparation are necessary to the effective management of a contamination threat.

2.2 Module 2, Contamination Threat Management Guide

Overview. The threat management process involves two parallel and interrelated activities: 1) Evaluating the threat, and 2) Making decisions regarding appropriate actions to take in response to the threat. The first step of the threat evaluation process involves the collection of information to help determine if the threat is **'possible'**; that is, do the circumstances of a threat

indicate the opportunity for contamination? Following the determination that the threat is 'possible', additional information is gathered to help determine if the threat is **'credible'**; that is, does the additional information corroborate the information already known about the threat? Finally, efforts are taken to **'confirm'** the contamination incident; that is, is there definitive evidence that the water has actually been contaminated with a harmful substance? This is a progressive evaluation in which more serious response actions are considered as the threat is elevated through these three stages.

There are a number of difficult management decisions that must be made before, during, and after a contamination threat, such as: 1) How to decide if an incident has occurred, as opposed to a hoax; 2) What actions to take in response to a threat; 3) How to determine that a perceived threat is not 'credible' and can be dismissed; and 4) How to manage a confirmed contamination incident.

Objectives. The objectives of Module 2 are to:

1) Present a framework for evaluating a water contamination threat and making decisions at key points in the process.
2) Describe the type of information that may be useful for conducting a threat evaluation.
3) Describe the actions that might be implemented in response to a contamination threat, giving consideration to the potential consequences of various actions.

Audience. The primary audience for this module is the water utility emergency response manager (WUERM), who will likely have some role in the threat management process throughout the response. Furthermore, other individuals that might be involved in the management of a contamination threat, such as members of law enforcement, the drinking water primacy agency, and the public health department, should also review this module.

Highlights. Module 2:

- Describes the three stages of a threat evaluation: possible, credible, and confirmed.
- Describes the information that might support both the threat evaluation and the response actions that might be considered at each of these stages.
- Identifies the types of individuals and organizations that might become involved at various stages of the contamination threat management process.
- Provides examples regarding the manner in which the threat management process is applied to different incident warnings.
- Contains various forms that might aid in the documentation of incident warnings and the subsequent threat evaluation process. The readers may find these forms useful in preparing their own Response Guidelines, described below in Section 3.3 below.

2.3 Module 3, Site Characterization and Sampling Guide

Overview. Site characterization is defined as the process of collecting information from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Objectives. The objectives of Module 3 are to:

1) Describe considerations for personnel involved in the planning or execution of site characterization activities in response to a water contamination threat.
2) Present protocols and procedures for the site investigation, field safety screening, rapid field testing, and sample collection.

Audience. Any individuals involved in planning or implementing site characterization activities are encouraged to review this module in its entirety. Laboratories that may tend to focus on Module 4 (Analytical Guide) may also find the information in Module 3 useful, particularly with respect to the screening activities that occur in the field and directly impact the safety considerations of the laboratory.

Highlights. Module 3:

- Provides an overview of planning for safe and effective site characterization.
- Describes the qualifications of individuals sent to the site, as well as the steps taken to ensure the safety of the site characterization team.
- Contains various sample forms that may be useful for planning and documenting the results of site characterization and sampling activities, including chain of custody. The readers may find these forms useful in preparing their own Response Guidelines, as described in Section 3.3.
- Describes field safety screening and the contents of a core and an expanded field test kit.
- Lists the contents of a model sample collection kit.
- Presents considerations for shipping the collected samples to the laboratory for analysis.

2.4 Module 4, Analytical Guide

Overview. The analytical guide presents an approach to the analysis of samples that may be collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples collected during site characterization. The framework is flexible and will allow the approach to be crafted based on available information about the threat and the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Objectives. The objectives of Module 4 are to:

1) Describe special laboratory considerations for handling and processing emergency water samples suspected of contamination with a harmful substance.
2) Present model approaches and procedures for analysis of water samples suspected of contamination with a known or unknown substance(s).
3) Encourage planners to develop site-specific analytical approaches that follow the general principles of the framework and model analytical approaches presented in Module 4.

Audience. This module should be reviewed by both laboratory and utility planners and by laboratory personnel.

Highlights. Module 4:

- Describes existing laboratory infrastructure for the analysis of water contaminants, including a link to a compendium of laboratories that might support utilities in the analysis of emergency water samples.
- Discusses considerations for the analysis of water samples collected during an emergency, including safety, quality assurance, and legal admissibility of scientific evidence.
- Summarizes those aspects of site characterization issues that relate to laboratory safety and analysis.
- Introduces a general approach for the analysis of unknowns, which integrates site characterization results to produce a rapid, defensible, and comprehensive analysis.
- Presents an analytical approach for chemicals and pathogens based on two forms of screening for specific classes of contaminants. This approach utilizes a combination of standardized methods and sound exploratory techniques.
- Provides examples of the customization of the analytical approach to specific laboratory objectives.

2.5 Module 5, Public Health Response Guide (in preparation)

Overview: Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interactions between the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Objectives: The objectives of Module 5 are to:

1) Identify the organizations and officials responsible for making and implementing public health response decisions for drinking water.
2) Describe the role of the drinking water utility in the public health response to a water contamination threat.
3) Develop communication protocols and structures within the responding public health agencies and also for communication with the public and the media.
4) Identify resources and techniques to aid in evaluation of public health consequences associated with specific contaminants.
5) Consider acute and chronic effects via ingestion, inhalation, and dermal exposure pathways.
6) Develop response options, including containment and public notification.
7) Identify potential short-term alternative water supplies.

Audience. The primary intended users of this module include water utility staff and entities that will assist small water utilities (e.g., drinking water primacy agencies). In addition, public health response agencies (e.g., public health departments) are encouraged to read this module since they will likely make the decisions regarding the public health response actions that are taken (e.g., public notification) during a water contamination threat.

Highlights. Module 5:

- Describes the organizations that may be involved in making public health decisions, various response options that may be considered, and the need for an effective communication plan.
- Describes the contaminant characteristics that should be considered when making public health decisions.
- Describes methods of estimating the spread of contaminated water and containment options.
- Discusses public notification, including applicable regulatory requirements, as a means of reducing or mitigating exposure and avoiding public panic, types of notifications, and information that is readily available or may be developed to educate the public (e.g., fact sheets).
- Discusses alternate water supply issues pertaining to domestic consumption, sanitation, fire-fighting, and needs of critical customers.

2.6 Module 6, Remediation and Recovery Guide (in preparation)

Overview. Following a confirmed water contamination incident, it will be necessary to remediate the system and demonstrate that the system has been successfully restored prior to resuming normal operation. This process involves a sequence of activities, including system characterization and selection of remedy options. Following implementation of the remediation plan, steps must be taken to demonstrate that the system can be returned to normal operation. Furthermore, plans will need to be made for the long-term supply of alternate drinking water during remediation. Module 6 describes the planning and implementation of these remediation and recovery activities, the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

Objectives: The objectives of Module 6 are to:

1) Identify the organizations and officials responsible for making and implementing decisions regarding remediation and recovery activities for contaminated drinking water.
2) Describe the role of the drinking water utility during the remediation and recovery stage of a contamination incident.
3) Describe how a systematic planning process can be applied to ensure that the right type, quantity, and quality of data are obtained to support the remediation and recovery activities.
4) Describes the process for selecting a remedial technology, both for treatment of contaminated drinking water and remediation of contaminated system components.
5) Present the issues and considerations associated with returning to normal operation following remediation and recovery activities.

Audience. The target audience for this module includes individuals that will be involved in system characterization, risk assessment, and remedial response action activities following a confirmed contamination incident. The target audience also includes decision-makers who will determine the need for long-term alternate water supplies, select remedial technologies, determine when to return to normal operations, and communicate with the public.

Highlights. Module 6:

- Presents procedures for characterization of the contaminated area.
- Describes considerations for providing a long-term alternate supply of drinking water during the remediation and recovery stage.
- Describes a flexible sequence of steps designed to select the appropriate remedial response to address a contaminated drinking water system.
- Describes regulations that must be considered when managing wastes generated from the remediation of a contaminated waste system.
- Presents special considerations for system restart with emphasis on public outreach and communication.

3 Application of the Response Protocol Toolbox

The following subsections list three main areas in which the RPTB may be applied, as well as some examples of those applications. Ultimately, the RPTB will be packaged in an electronic format that will allow users to easily integrate the elements best suited to their individual needs and the unique aspects of their water supply. Accordingly, the intent of the material in this section is to encourage users to take advantage of the robust and flexible nature of this toolbox in crafting their own plans.

3.1 Planning a Response to a Contamination Threat

It is important to remember that the RPTB is much more effective as a **planning tool** than as a reference during an actual contamination threat when decisions will need to be made rapidly and with limited information. As a planning tool, it provides a framework to guide the utility's response to contamination threats. These plans can help identify credible threats and dismiss hoaxes, and support decisions regarding response actions that are appropriate for the situation. To increase the effectiveness of these plans, utilities should exercise them under conditions that simulate the stresses resulting from an actual contamination threat.

The RPTB does not attempt to define who will be involved in various stages of a response. These decisions are best left to local authorities, who have an intimate knowledge of the organizations and systems that exist within their water utility, government, and community for providing support during an emergency. For example, the utility and local or state authorities will need to determine:

- Who will respond?
- Who will sample?
- Who will perform analyses?
- Who will make public health decisions?
- Who will manage remediation and recovery activities?

The specific application of the RPTB as a planning tool is based on the particular function and responsibility of the user in responding to a drinking water contamination threat. Figure O-2 illustrates several potential uses of the RPTB by various parties. Figure O-2 is not intended to prescribe a particular use, nor is it intended to be comprehensive. Rather, it is intended to provide several examples and suggestions about how various users might apply the modules that comprise the RPTB.

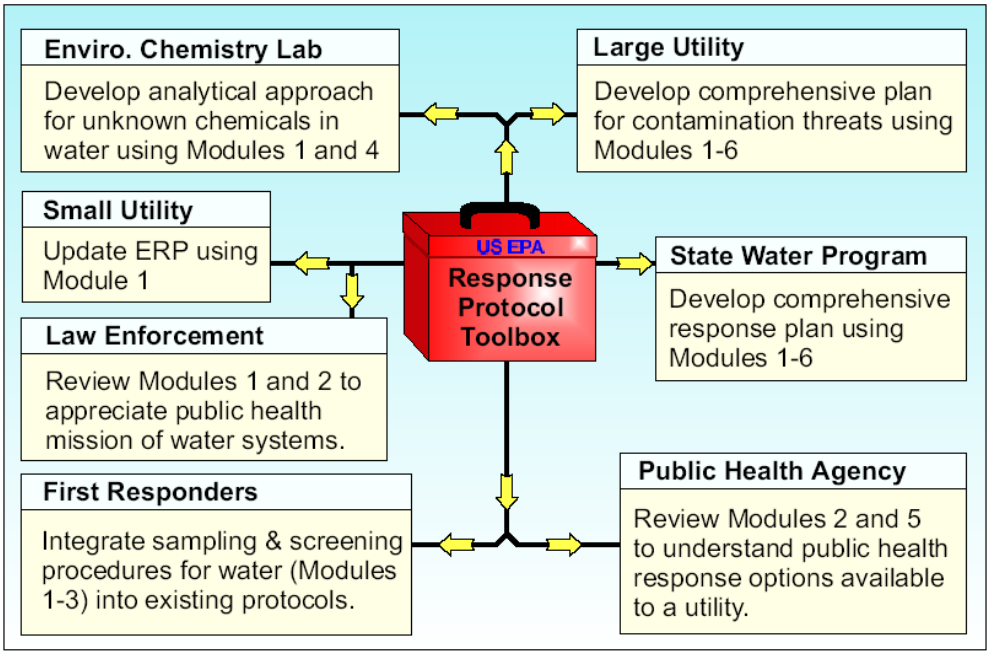


Figure O-2. Examples of the use of the Response Protocol Toolbox (RPTB) by various interest groups.

3.2 Revising "Emergency Response Plans"

Information contained in the RPTB may be helpful in the revision of the utility's emergency response plan (ERP), particularly for contamination threats. It should be noted, however, that there is no regulatory requirement to use the RPTB in the revision of the ERP. Guidance on the preparation of ERPs is being prepared separately (EPA, "Drinking Water Model Emergency Response Plan," in preparation). Some of the information from the RPTB that the utilities may find useful in revising their ERPs are:

- The discussion of the nature of the contamination threats (Module 1).
- The framework and approach for managing contamination threats (Module 2).
- The procedures for characterizing a potential contamination site and collecting samples (Module 3).
- A framework for developing an analytical approach for water samples potentially containing an unidentified contaminant (Module 4).
- The public health response measures considered during and after an incident (Module 5).
- Steps in planning for remediation and recovery following a confirmed contamination incident (Module 6).

It is hoped that the RPTB will provide answers to the multitude of questions utilities may ask when revising an ERP to encompass a contamination threat.

3.3 Developing "Response Guidelines"

Although not a formal part of an ERP, utilities may wish to develop Response Guidelines (RGs), which are essentially a field guide for responding to contamination threats. Note that there is no regulatory requirement to do this, but it may be a prudent step in preparing for a response to contamination threats. RGs are discussed in Module 1, and a sample RGs outline is presented in the appendix to Module 1. Development of RGs can be facilitated by extracting information directly from RPTB, including: protocols, figures, tables, forms, etc. and integrating them into a user's own RGs. In this manner, the RPTB can be customized to meet a user's specific needs and responsibilities in responding to a contamination threat.

3.4 Other Applications of the RPTB

Several other types of guides could be crafted from material in the RPTB to meet the needs and responsibilities of various parties, such as EPA, states, utilities, laboratories, and others. These include, but are not limited to, the following:

- Drinking Water Primacy Agency Response Guideline: These will be more generic than a utility RGs and may help the primacy agency to fulfill various responsibilities, such as assisting smaller water utilities in responding to contamination threats.

- Small system guide: The needs and capabilities of small systems vary greatly. Some small systems may be capable of customizing the RPTB to their needs. Others will need some authority, such as EPA or the drinking water primacy agency, to do this for them.

- Laboratory Guide (LG) for laboratories: Module 4 presents a general analytical guide developed from a national perspective. Laboratories may prepare a customized LG based on their local need, capabilities, and responsibilities.

- Emergency Responder Guide (ERG): This guide is designed for responders that will help utilities, particularly with site characterization activities. For example, responders may integrate the information and procedures from part of the RPTB, such as Module 3, into their existing procedures.

- Public Health Guide: Utilities may prepare a guide or fact sheet for their local public health department and water customers explaining the benefits of various public health response actions. It should also briefly summarize relevant system operations (i.e., ability to isolate certain components).

- Remediation and Recovery Guide: This utility document may detail the technical plan for returning the system to service under various contamination scenarios.

- Consumer Guide: Not a technical document, this guide might be aimed at water customers to encourage them to prepare for situations in which there are temporary restrictions on water usage. This could be a variation on existing disaster preparation guides.

- Law Enforcement Guide: This guide may explain to the law enforcement community relevant aspects of water utility operation and contamination response planning. This guide may facilitate coordination in planning and response to contamination threats.

- Utility Coordination Guide: Larger water systems that supply water to smaller, independent water utilities may prepare a suitable guide for their smaller associates. Identifying these roles, capabilities and responsibilities may prove valuable to all parties in preparing a response to a contamination threat or incident.

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-007
www.epa.gov/safewater/security
December 2003

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

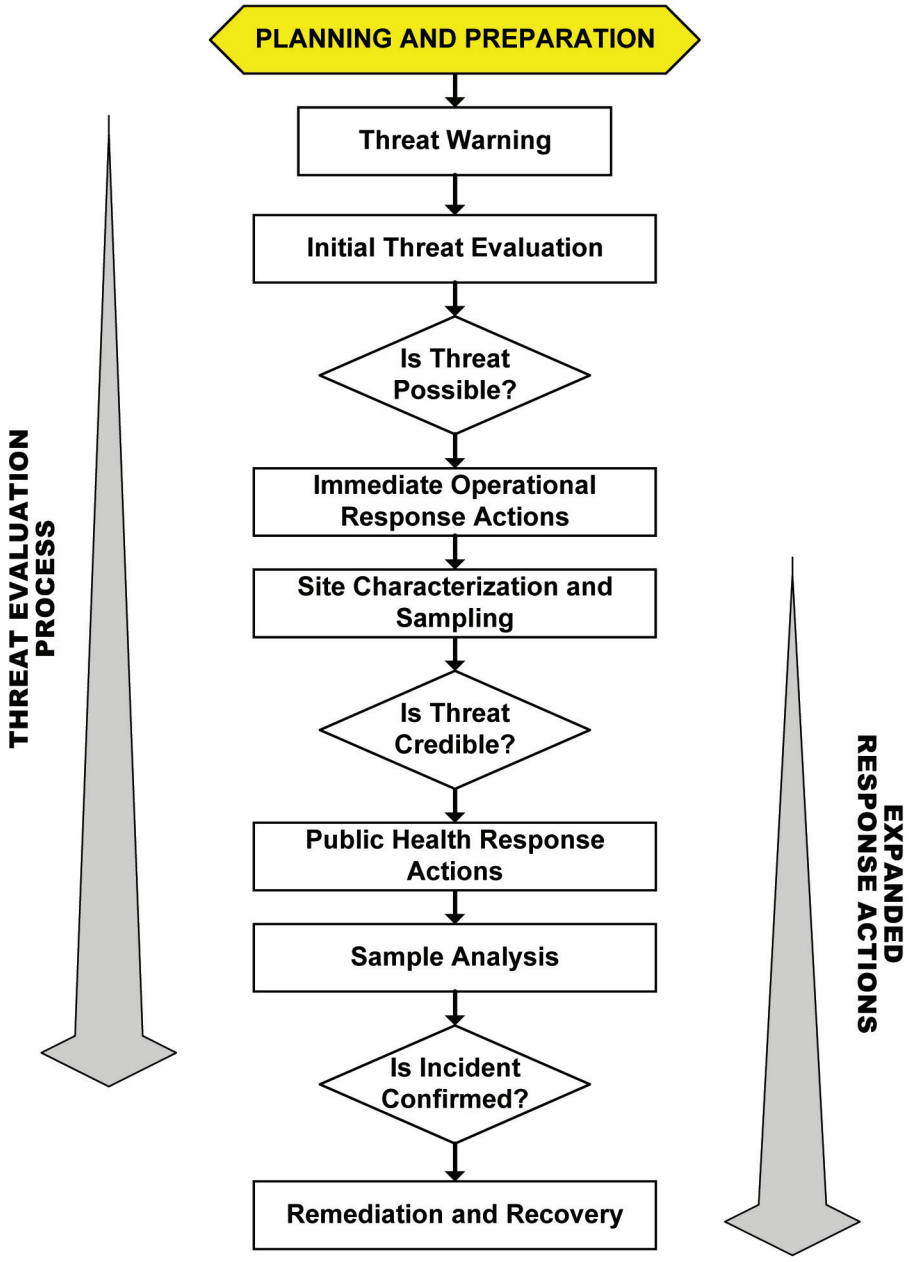
Interim Final - December 2003

Module 1: Water Utilities Planning Guide

Response Protocol Toolbox:
Planning for and Responding to Drinking Water Contamination Threats and Incidents

Module 1: Water Utilities Planning Guide

Interm Final - December 2003



OTHER RESPONSE PROTOCOL TOOLBOX MODULES

Module 1: Water Utility Planning Guide *(December 2003)*
Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to prepare for response to contamination threats and incidents.

Module 2: Contamination Threat Management Guide *(December 2003)*
Module 2 presents the overarching framework for management of contamination threats to the drinking water supply. The threat management process involves two parallel and interrelated activities: 1) evaluating the threat, and 2) making decisions regarding appropriate actions to take in response to the threat.

Module 3: Site Characterization and Sampling Guide *(December 2003)*
Module 3 describes the site characterization process in which information is gathered from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Module 4: Analytical Guide *(December 2003)*
Module 4 presents an approach to the analysis of samples collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples that may contain an unknown contaminant. The framework is flexible and will allow the approach to be crafted based on the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Module 5: Public Health Response Guide *(available March 2004)*
Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interactions among the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Module 6: Remediation and Recovery Guide *(available March 2004)*
Module 6 describes the planning and implementation of remediation and recovery activities that would be necessary following a confirmed contamination incident. The remediation process involves a sequence of activities, including: system characterization; selection of remedy options; provision of an alternate drinking water supply during remediation activities; and monitoring to demonstrate that the system has been remediated. Module 6 describes the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

TABLE OF CONTENTS

1 INTRODUCTION: WHY SHOULD I READ THIS MODULE?.....11

2 WHAT ARE CONTAMINATION THREATS AND INCIDENTS? 12

2.1 OVERVIEW OF CONTAMINATION THREATS AND INCIDENTS.....12
2.2 WARNINGS SIGNS OF A CONTAMINATION THREAT.....16

3 HOW SHOULD I RESPOND TO WATER CONTAMINATION THREATS?.....19

3.1 I'M JUST A UTILITY—WHY DO I NEED TO DO ANYTHING AT ALL?.....19
3.2 DUE DILIGENCE—WHEN HAVE I DONE ENOUGH?.....19

4 WHAT CAN I DO TO PREPARE? 22

4.1 KNOW YOUR WATER SYSTEM.....22
4.1.1 CONSTRUCTION AND OPERATION.....22
4.1.2 PERSONNEL 23
4.1.3 CUSTOMERS.....23
4.2 UPDATE EMERGENCY RESPONSE PLANS FOR INTENTIONAL CONTAMINATION 24
4.3 DEVELOP RESPONSE GUIDELINES FOR INTENTIONAL CONTAMINATION 24
4.4 ESTABLISH STRUCTURE FOR INCIDENT COMMAND.....24
4.5 DEVELOP INFORMATION MANAGEMENT STRATEGY.....29
4.6 ESTABLISH COMMUNICATION AND NOTIFICATION STRATEGY.....30
4.7 PERFORM TRAINING AND DESK/FIELD EXERCISES.....33
4.8 ENHANCE PHYSICAL SECURITY 34
4.9 ESTABLISH BASELINE MONITORING PROGRAM 34
4.10 UTILIZE AND UNDERSTAND ON-LINE MONITORING.....35

5 REFERENCES AND RESOURCES.....36

6 APPENDICES 38

6.1 SAMPLE OUTLINE OF RESPONSE GUIDELINE.....38
6.2 U.S. GOVERNMENT RESPONSE PLANS.....39
6.2.1 NATIONAL RESPONSE PLAN.....39
6.2.2 FEDERAL RESPONSE PLAN 39
6.3 ON-LINE MONITORING SYSTEMS 43
6.3.1 CONVENTIONAL SYSTEMS 43
6.3.2 EARLY WARNING SYSTEMS 43

LIST OF TABLES

TABLE 1-1: CONTAMINANT CLASSES, THEIR AVAILABILITIES, AND RESTRICTIONS.....14
TABLE 1-2: PRIORITIZATION CRITERIA FOR POTENTIAL WATER CONTAMINANTS.....16

LIST OF FIGURES

FIGURE 1-1: SUMMARY OF THREAT WARNINGS.....17
FIGURE 1-2: OVERVIEW OF RESPONSE TO A CONTAMINATION THREAT.....21
FIGURE 1-3: EXPANSION OF, AND CHANGES TO, INCIDENT COMMAND STRUCTURE FOR THE THREE THREAT EVALUATION STAGES.....27
FIGURE 1-4: SAMPLE COMMUNICATION SCHEMES FOR THE THREE THREAT EVALUATION STAGES.....31
FIGURE 1-5: OVERVIEW OF POTENTIAL EXTERNAL NOTIFICATIONS 32

ACRONYMS

AWWARF	American Water Works Association Research Foundation
C/B	Chemical/Biological
CD	Compact disk
CDC	Centers for Disease Control and Prevention
DBP	Disinfection by-product
DHS	Department of Homeland Security
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOS	Department of State
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
ERP	Emergency response plans
ESF	Emergency support function
EWS	Early warning system
FBI	Federal Bureau of Investigation
FCO	Federal coordinating officer
FEMA	Federal Emergency Management Agency
FRP	Federal Response Plan
GIS	Geographic information system
GSA	Government services agency
HazMat	Hazardous materials
HHS	Department of Health and Human Services
IC	Incident commander
ICS	Incident Command System
ILSI	International Life Sciences Institute Risk Science Institute
IO	Information officer
JIC	Joint information center
JOC	Joint operations center
LFA	Lead federal agency
LO	Liaison officer
LPoC	Laboratory point of contact
LRN	Laboratory Response Network
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NIIMS	National Interagency Incident Management System
NIMS	National Incident Management System
NRC	Nuclear Regulatory Commission
NRP	National Response Plan
OSC	On-scene coordinator
PDD	Presidential decision directive
RG	Response guideline

RPTB	Response Protocol Toolbox
RST	Regional support team
SCADA	Supervisory control and data acquisition
SDWA	Safe Drinking Water Act
TOC	Total organic carbon
URL	Uniform resource locator
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
UV	Ultraviolet
WCIT	Water contaminant information tool
WHO	World Health Organization
WUERM	Water utility emergency response manager
WUOCM	Water utility emergency operations center manager

GLOSSARY

Definitions in this glossary are specific to the Response Protocol Tool Box but conform to common usage as much as possible.

Agency – a division of government with a specific function, or a non-governmental organization (e.g., private contractor, business, etc.) that offers a particular kind of assistance. In the incident command system, agencies are defined as jurisdictional (having statutory responsibility for incident mitigation) or assisting and/or cooperating (providing resources and/or assistance).

Agency Representative – an individual assigned to an incident from an assisting or cooperating agency who has been delegated authority to make decisions on matters affecting that agency's participation at the incident.

Assisting Agency – an agency directly contributing tactical or service resources to another agency.

Bioterrorism Act – the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

Chain of Command – a series of management positions in order of authority.

'Confirmatory' Stage – the third stage of the threat evaluation process from the point at which the threat is deemed 'credible' through the determination that a *contamination incident* either has or has not occurred.

'Confirmed' – in the context of the *threat evaluation* process, a water contamination incident is 'confirmed' if the information collected over the course of the threat evaluation provides definitive evidence that the water has been contaminated.

Contamination Site – the location where a contaminant is known or suspected to have been introduced into a drinking water system. For example, a distribution system storage tank where a security breach has occurred may be designated as a suspected contamination site. The contamination site will likely be designated as an *investigation site* for the purpose of *site characterization*.

Cooperating Agency – an agency supplying assistance, other than direct tactical or support functions, or resources to the incident control effort (e.g., Red Cross, telephone companies).

Coordination – the process of systematically analyzing a situation, developing relevant information, and informing the appropriate command authority of viable alternatives for selection of the most effective combination of available resources to meet specific objectives. The coordination process (which can be either intra- or inter-agency) does not involve dispatch actions. However, personnel responsible for coordination may perform command or dispatch functions within the limits established by specific agency delegations, procedures, legal authority, etc.

'Credible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'credible' if information collected during the threat evaluation process corroborates information from the *threat warning*.

'Credible' Stage – the second stage of the threat management process from the point at which the threat is deemed 'possible' through the determination as to whether or not the threat is 'credible'.

Drinking Water Primacy Agency – the *agency* that has primary enforcement responsibility for national drinking water regulations, namely, the Safe Drinking Water Act as amended. Drinking water primacy for a particular state may reside in one of a variety of agencies, such as health departments, environmental quality departments, etc. The drinking water primacy agency is typically the State Health Agency or the State Environmental Agency. The drinking water primacy agency may also play the role of *technical assistance provider* to drinking water utilities.

Emergency Operations Center – a pre-designated facility established by an agency or jurisdiction to coordinate the overall agency or jurisdictional response and support to an emergency.

Emergency Response Plan – a document that describes the actions that a drinking water utility would take in response to various emergencies, disasters, and other unexpected incidents.

Event – a planned, non-emergency activity (e.g., parades, concerts, sporting events, etc.).

Immediate Operational Response – an action taken in response to a 'possible' contamination threat in an attempt to minimize the potential for exposure to the potentially contaminated water. Immediate operational response actions will generally have a negligible impact on consumers.

Incident – a confirmed occurrence that requires response actions to prevent or minimize loss of life or damage to property and/or natural resources. A drinking water contamination incident occurs when the presence of a harmful contaminant has been confirmed.

Incident Command System – a standardized on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure appropriate for the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Incident Commander – the individual responsible for the management of all incident operations.

Incident Objectives – statements of guidance and direction necessary for the selection of appropriate strategy(ies), and the tactical direction of resources. Incident objectives are based on realistic expectations of what can be accomplished when all allocated resources have been

effectively deployed. Incident objectives must be achievable and measurable, yet flexible enough to allow for strategic and tactical alternatives.

Information Officer – the individual responsible for interfacing with the public and media or with other agencies requiring information directly from the incident. Under the ICS, there is only **one** Information Officer per incident.

Investigation Site – the location where site characterization activities are performed. If a suspected *contamination site* has been identified, it will likely be designated as a primary investigation site. Additional or secondary investigation sites may also be identified due to the potential spread of a contaminant.

Jurisdiction – the range or sphere of authority. Public agencies have jurisdiction at an incident related to their legal responsibilities and authority for incident mitigation. Jurisdictional authority at an incident can be political/geographic (e.g., city, county, State, or Federal boundary lines) or functional (e.g., police department, health department, etc.).

Multi-jurisdiction Incident – an incident requiring action from multiple agencies that have a statutory responsibility for incident mitigation. In ICS, these incidents will be managed under Unified Command.

National Interagency Incident Management System – a program developed by the National Wildfire Coordinating Group consisting of five major subsystems which collectively provide a total systems approach to all-risk incident management. The subsystems are the Incident Command System, Training, Qualifications and Certification, Supporting Technologies, and Publications Management.

Notification – the process of communication information to interested parties.

Opportunity Contaminant – contaminants that might be readily available in a particular area, even though they may not be highly toxic or infectious or easily dispersed and stable in treated drinking water.

'Possible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'possible' if the circumstances of the *threat warning* appear to have provided an opportunity for contamination.

'Possible' Stage – the first stage of the threat management process from the point at which the *threat warning* is received through the determination as to whether or not the threat is 'possible.'

Quality Assurance – an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement, to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Control – the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the

stated requirements established by the client; operational techniques and activities that are used to fulfill requirements for quality.

Response Guidelines – a manual designed to be used **during** the response to a water contamination threat. Response Guidelines should be easy to use and contain forms, flow charts, and simple instructions to support staff in the field or decision officials in the *Emergency Operations Center* during management of a crisis.

Secure Area – a locked space, such as a cabinet or vault, with access restricted to authorized personnel.

Site Characterization – the process of collecting information from an *investigation site* in order to support the evaluation of a drinking water contamination threat. Site characterization activities include the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection.

Technical Assistance Provider – any organization or individual that provides assistance to drinking water utilities in meeting their mission to provide an adequate and safe supply of water to their customers. The *drinking water primacy agency* may serve as a technical assistance provider.

Threat – an indication that a harmful *incident*, such as contamination of the drinking water supply, may have occurred. The threat may be direct, such as a verbal or written threat, or circumstantial, such as a security breach or unusual water quality.

Threat Evaluation – part of the threat management process in which all available and relevant information about the threat is evaluated to determine if the threat is 'possible' or 'credible', or if a contamination *incident* has been 'confirmed.' This is an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

Threat Management – the process of evaluating a contamination threat and making decisions about appropriate response actions. The threat management process includes the parallel activities of the *threat evaluation* and making *response decisions*. The threat management process is considered in three stages: 'possible', 'credible', and 'confirmatory.' The severity of the threat and the magnitude of the response decisions escalate as a threat progresses through these stages.

Threat Warning – an unusual occurrence, observation, or discovery that indicates a potential contamination incident and initiates actions to address this concern.

Unified Command – a unified team effort which allows all agencies with responsibility for the incident, either geographic or functional, to manage an incident by establishing a common set of incident objectives and strategies. This is accomplished without losing or abdicating agency authority, responsibility, or accountability.

Unity of Command – the concept by which each person within an organization reports to only one designated person.

Vulnerability Assessment – a systematic process for evaluating the susceptibility of critical facilities to potential threats and identifying corrective actions that can reduce or mitigate the risk of serious consequences associated with these threats.

Water Contamination Incident – a situation in which a contaminant has been successfully introduced into the system. A water contamination incident may or may not be preceded by a water contamination threat

Water Contamination Threat – a situation in which the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. Compare *water contamination threat* with *water contamination incident.* Note that threatening a water system may be a crime under the Safe Drinking Water Act as amended by the Bioterrorism Act.

Water Utility Emergency Operations Center Manager – the individual responsible for carrying out the plan for emergency operations at the water utility during an emergency incident.

Water Utility Emergency Response Manager (WUERM) – the individual(s) within the drinking water utility management structure that has the responsibility and authority for managing certain aspects of the utility's response to an emergency (e.g., a contamination threat) particularly during the initial stages of the response. The responsibilities and authority of the WUERM are defined by utility management and will likely vary based on the circumstances of a specific utility.

1 Introduction: Why Should I Read this Module?

The primary audience for this module is drinking water utilities, which need to **plan** for and **practice** managing and responding to contamination attacks. However, there are many other groups that may be involved in responding to water contamination *threats* and *incidents*, and they also may benefit from reviewing this module to assist in their **planning** activities. These groups include analytical laboratories, emergency responders, state *drinking water primacy agencies*, *technical assistance providers*, public health officials, federal agencies (including EPA), and law enforcement agencies, among others. The objectives of this module are:

- To familiarize the reader with the nature and warning signs of water contamination threats and incidents. The reader will learn that drinking water contamination incidents are possible and that contamination threats are probable.
- To describe the overall framework for responding to a range of contamination threats, ranging from hoaxes to confirmed contamination incidents. This framework, the primary focus of the Response Protocol Toolbox (RPTB), is one of the highest water security priorities identified by the water sector and the EPA.
- To help readers prepare for responding to contamination threats through: 1) Careful planning; 2) Development of *Response Guidelines*; 3) Establishing *notification* procedures and internal *chain of command*; and 4) Performing training exercises.

This module is organized into five sections as described below.

Section 1: Introduction: describes the objectives and overall organization of this module.

Section 2: What are Contamination Threats and Incidents? Provides background information on the contamination threat to water systems, including a discussion of potential warning signs of contamination.

Section 3: How Should I Respond to Water Contamination Threats? Discusses the need for response and introduces the concept of 'due diligence' in responding to contamination threats.

Section 4: What Can I do to Prepare? Highlights several areas in which utilities can enhance their preparedness for contamination threats.

Section 5: References and Resources: Lists the references used in the development of this module as well as additional information resources.

Section 6: Appendices: Provides a sample outline for utility Response Guidelines, describes the roles of federal agencies under two U.S. government response plans, and provides an overview of drinking water security applications for on-line monitoring systems.

2 What are Contamination Threats and Incidents?

2.1 Overview of Contamination Threats and Incidents

Both *water contamination threats* and *water contamination incidents* could be designed to interrupt the delivery of safe water to a population, interrupt fire protection, create public panic, or cause disease or death in a population. A water contamination threat occurs when the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. A water contamination incident occurs when a contaminant is successfully introduced into the water supply. The water contamination incident may be preceded by a threat, but not always. Both water contamination threats and incidents may be of particular concern due to the range of potential consequences:

- Creating an adverse impact on public health within a population.
- Disrupting system operations and interrupting the supply of safe water.
- Causing physical damage to system infrastructure.
- Reducing public confidence in the water supply.
- Long-term denial of water and the cost of remediation and replacement.

Some of these consequences would only be realized in the event of a successful contamination incident; however, the mere threat of contamination can have an adverse impact on a water system if improperly handled.

In characterizing any threat, both the **possibility** and **probability** should be considered. A general assessment of the threat of intentional contamination of drinking water indicates that it is **possible** to cause varying degrees of harm by contaminating a water system. Specifically, this assessment indicates that:

- Only a few contaminants have the potential to produce widespread death or disease in a population. These contaminants include concentrated pathogens, biotoxins, and a few highly toxic chemicals that may remain stable in water long enough to adversely impact public health.
- A larger group of contaminants could produce localized death or disease in a segment of a population, including several dozen toxic chemicals.
- Hundreds of contaminants could potentially disrupt service or undermine consumer confidence but would not result in death or disease in the population.

While it is important to consider the range of possibilities associated with a particular threat, assessments are typically based on the **probability** of a particular occurrence. Determining probability is somewhat subjective, and is often based on intelligence and previous incidents. There are historical accounts of intentional contamination of drinking water supplies with biological or chemical contaminants, but most have been associated with wartime activities (http://www.who.int/emc/pdfs/BIOWEAPONS_FULL_TEXT2.pdf). The few documented accounts of intentional contamination of public water systems in the U.S. have not resulted in any reported fatalities. The American Water Works Association Research Foundation (AWWARF) is preparing a report on this subject (AWWARF, 2003). Based on these accounts, it would appear that the probability of a successful contamination incident on a drinking water system is relatively low. However, there has been a reported increase in the interest of various terrorist groups in biological and chemical weapons. Furthermore, some

intelligence information indicates that terrorist organizations have considered water infrastructure as a possible target. Thus, the potential for such an incident does exist.

While the probability of an actual contamination incident may be considered low relative to other modes of attack, the probability of the **threat** of contamination may be relatively high compared to other forms of attack. Many of the apparent security breaches at drinking water utilities that have occurred since 9/11 have been perceived as potential contamination incidents. Although a few threats have been verbal, most have been circumstantial, such as a low-flying airplane over a reservoir or a lock cut from the hatch of a distribution system storage tank. Given the possibility of contamination, many utilities chose to treat these security breaches as potential contamination threats. These incidents demonstrate the need for a protocol to guide an appropriate response to contamination threats.

In order to prepare for contamination threats, there is a general sense that it is necessary to generate a list of priority contaminants. However, the generation of such a list is a significant challenge due to the wide range of adverse effects that might result from intentional contamination, as discussed at the beginning of this section. Furthermore, no list of contamination threats should be considered definitive or complete. A document prepared under the auspices of the World Health Organization succinctly sums up this dilemma, and places it in the context of planning for a response to a biological or chemical contamination incident:

> "A central consideration in such preparedness planning is that it is neither possible nor necessary to specifically plan for attack by all possible biological and chemical agents. If a country is seeking to increase its preparedness to counter the effects of biological and chemical attacks, the targeting of its preparation and training on a limited but well chosen group of agents will provide the necessary capability to deal with a far wider range of possibilities. Knowledge of the general properties of this representative group of agents will enable certain measures to be taken against virtually any other agent. In addition to being impractical from a preparedness perspective, long and exhaustive lists of agents also give a misleading impression of the extent of possible threats."
>
> In: *Public health response to biological and chemical weapons: WHO guidance, 2nd edition (Draft, March 2003),* (http://www.who.int/csr/delibepidemics/biochemguide/en/index.html)

Nonetheless, many federal and private organizations have generated contaminant lists that reflect the specific priorities and assumptions of that organization. For instance, the military is largely concerned with safeguarding the readiness of our combat troops and hence focuses on the classical weapons of chemical and biological warfare, while other organizations are more focused on infectious diseases. While it is possible to use the experience gained from the preparation of these lists, it is very important to consider the special needs and challenges presented by safeguarding public health through protection of the drinking water supply. For instance, there is essentially no tolerance by the public toward sudden disease and death from tainted water supplies. Another challenge is that drinking water is used not only for consumption but also for other uses such as fire protection, sanitation, and industrial processes. In fact, most treated drinking water is used for purposes other than consumption.

Table 1-1 presents a number of contaminant classes that would potentially have an adverse impact if introduced into the drinking water supply. This is not intended to be an exhaustive list, and there may be many others that may be used to contaminate a water supply.

Table 1-1 Contaminant Classes, their Availabilities, and Restrictions

Class	Examples (not exhaustive)	Sources	Limited access?
MICROBIOLOGICAL CONTAMINANTS			
Bacteria	*Bacillus anthracis, Brucella* spp., *Burkholderia* spp., *Campylobacter* spp., *Clostridium perfringens, E. coli* O157:H7, *Francisella tularensis, Salmonella typhi, Shigella* spp., *Vibrio cholerae, Yersinia pestis, Yersinia enterocolitica*	Naturally occurring, Microbiological laboratories[1], state-sponsored programs	Yes for Select Agents
Viruses	Caliciviruses, Enteroviruses, Hepatitis A/E, Variola, VEE virus	Naturally occurring, Microbiological laboratories[1], state-sponsored programs	Yes for Select Agents
Parasites	*Cryptosporidium parvum, Entamoeba histolytica, Toxoplasma gondii*	Naturally occurring, Microbiological laboratories[1]	No
CHEMICAL CONTAMINANTS - Inorganic			
Corrosives and caustics	Toilet bowl cleaners (hydrochloric acid), tree-root dissolver (sulfuric acid), drain cleaner (sodium hydroxide)	Retail, industry	No
Cyanide salts or cyanogenics	Sodium cyanide, potassium cyanide, amygdalin, cyanogen chloride, ferricyanide salts	Supplier, industry (esp. electroplating)	Yes
Metals	Mercury, lead, osmium, their salts, organic compounds, and complexes (even those of iron, cobalt, copper are toxic at high doses)	Industry, supplier, laboratory	Yes[2]
Nonmetal oxyanions, organo-nonmetals	Arsenate, arsenite, selenite salts, organoarsenic, organoselenium compounds	Some retail, industry, supplier, laboratory	Yes[3]
CHEMICAL CONTAMINANTS - Organic			
Fluorinated organics	Sodium trifluoroacetate (a rat poison), fluoroalcohols, fluorinated surfactants	Supplier, industry, laboratory	Yes
Hydrocarbons and their oxygenated and/or halogenated derivatives	Paint thinners, gasoline, kerosene, ketones (e.g., methyl isobutyl ketone), alcohols (e.g., methanol), ethers (e.g., methyl *tert*-butyl ether or MTBE), halohydrocarbons (e.g., dichloromethane, tetrachloroethene)	Retail, industry, laboratory, supplier	No
Insecticides	Organophosphates (e.g., Malathion), chlorinated organics (e.g., DDT), carbamates (e.g., Aldicarb) some alkaloids (e.g., nicotine)	Retail, industry, supplier (varies with compound)	Yes
Malodorous, noxious, foul-tasting, and/or lachrymatory chemicals[4]	Thiols (e.g., mercaptoacetic acid, mercaptoethanol), amines (e.g., cadaverine, putrescine), inorganic esters (e.g., trimethylphosphite, dimethylsulfate, acrolein)	Laboratory, supplier, police supply, military depot	Yes
Organics, Water-miscible	Acetone, methanol, ethylene glycol (antifreeze), phenols, detergents	Retail, industry, supplier, laboratory	No

Class	Examples (not exhaustive)	Sources	Limited access?
Pesticides other than insecticides	Herbicides (e.g., chlorophenoxy or atrazine derivatives), rodenticides (e.g., superwarfarins, zinc phosphide, α-naphthyl thiourea)	Retail, industry, agriculture, laboratory	Yes
Pharmaceuticals	cardiac glycosides, some alkaloids (e.g., vincristine), antineoplastic chemotherapies (e.g., aminopterin), anticoagulants (e.g., warfarin). Includes illicit drugs such as LSD, PCP, and heroin.	Laboratory, supplier, pharmacy, some from a natural source	Yes
SCHEDULE 1 CHEMICAL WARFARE AGENTS			
Schedule 1 Chemical Weapons	organophosphate nerve agents (e.g., sarin, tabun, VX), vesicants, [nitrogen and sulfur mustards (chlorinated alkyl amines and thioethers, respectively)], Lewisite	Suppliers, military depots, some laboratories	Yes
BIOTOXINS			
Biologically produced toxins	Biotoxins from bacteria, plants, fungi, protists, defensive poisons in some marine or terrestrial animals. Examples include ricin, saxitoxin, botulinum toxins, T-2 mycotoxins, microcystins.	Laboratory, supplier, pharmacy, natural source[5], state-sponsored programs	Yes
RADIOLOGICAL CONTAMINANTS			
Radionuclides	Does not refer to nuclear, thermonuclear, or neutron bombs. Radionuclides may be used in medical devices and industrial irradiators (Cesium-137 Iridium-192, Cobalt-60, Strontium-90). Class includes both the metals and salts.	Laboratory, state sources, waste facilities	Yes[2]

1. The quantity of bacteria, viruses, or parasites needed for widespread contamination of a water system is not available in a typical clinical laboratory, although the seed cultures could be available. For viruses, vaccine production-grade volumes would be needed, requiring special equipment and facilities, perhaps with state-sponsorship.
2. Availability may be commercially limited for the more toxic metals, especially the heavy metals, which can be quite expensive. Iron and copper are readily available, but not usually in soluble (bio-available) forms.
3. Availability of arsenicals and selenium compounds in the retail sector has been reduced owing to environmental regulations, but such products can occasionally be found as part of older inventories of merchandise, especially in small-town hardware stores. Supplies of such materials may generally be too small to cause concern.
4. This grouping includes riot-control agents and other mucous membrane irritants.
5. The quantity available from laboratories, suppliers, and pharmacies needed for widespread contamination of a water system are typically not available from these sources. Many biotoxins that occur naturally would need to be purified or prepared to be of significant concern to water, which could make production beyond the capabilities of most terrorists.

The specific contaminants in Table 1-1 do not directly correspond to the highest priority contaminants; the table is merely illustrative of the relevant contaminant classes. The list of high priority contaminants was used to inform the development of the material in the RPTB (particularly Module 4). The list of high priority contaminants is not included in the RPTB for two reasons. First, as discussed above, such lists are inherently incomplete and hence may provide a false sense of security. Second, such a list could be used with malicious intent if included in a widely circulated document. Accordingly, to support emergency management of water threats and incidents, a resource for contaminant specific information, the Water Contaminant Information Tool (WCIT), is being developed specifically for use by the water sector. The WCIT, along with related information resources, is described in more detail in Module 2, Appendix 8.9.

In reviewing the contaminant classes listed in Table 1-1, it may be apparent that many are not tightly controlled and are considered to be readily available. Most threat analysts consider availability to be the most important characteristic of a contaminant that might be used in a terrorist or criminal activity. The phrase *opportunity contaminant* has been used to describe contaminants that might be readily available even though they may be considered less than optimal from a lethality or dissemination standpoint. In many cases, specific opportunity contaminants may be more readily available on a regional or local basis. For example, a particular industrial chemical or pesticide may be produced at a facility in close proximity to the water treatment plant and its associated distribution system. **Such site specific considerations should be incorporated into a utility's planning and response activities,** particularly with regards to *threat management* (Module 2) and *analytical approach* (Module 4).

In addition to availability, there are other factors that should be considered to better understand the contamination threat to water. Therefore, a broad group of potential contaminants, similar to those contained in Table 1-1, were prioritized with respect to their ability to adversely impact public health. The criteria used to prioritize the contaminants are described in Table 1-2. This prioritization was not intended to be comprehensive for all potential threats to water, but rather to be inclusive of contaminant classes that warrant consideration during the evaluation of a contamination threat or the analysis of a water sample for an unknown contaminant.

Table 1-2. Prioritization Criteria for Potential Water Contaminants

Criterion	Description
Aesthetic impacts	Changes in appearance, odor, or taste of contaminated water that might alert a consumer to the potential danger.
Availability	The ease with which the material can be obtained, synthesized, or harvested from natural sources.
Chlorine resistance	The time that a contaminant remains toxic or infectious after introduction into water containing a chlorine residual under typical distribution system conditions.
Dispersion	The ease with which a contaminant can be effectively dispersed in water.
Handling difficulty	The technical challenges associated with handling the material and introducing it into water.
Outcome of exposure	The health effects within the population resulting from exposure to the contaminant.
Potency	The amount of contaminant that would be required to contaminate a reference volume of water at a lethal or infectious dose. The smaller the amount of material, the higher the rank.
Public fear factor	Perception of the public regarding the risks associated with the contaminant.
Stability	The time that a contaminant remains toxic or infectious after introduction into an aqueous environment.
Storability	The time that a contaminant remains toxic or infectious while in storage.

2.2 Warnings Signs of a Contamination Threat

A *threat warning* is an occurrence or discovery that indicates a potential contamination threat that triggers an evaluation of the threat. The use of information about a threat warning during the initial stage of the *threat evaluation* process is described in more detail in Module 2. It is important to note that these warnings must be evaluated in the context of typical utility activity and previous experience in order to avoid **false alarms**. Figure 1-1 summarizes several potential threat warnings.

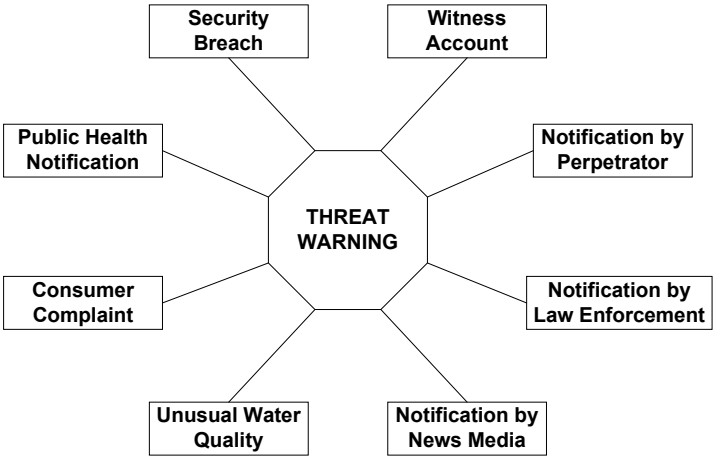


Figure 1-1. Summary of Threat Warnings

The threat warnings shown in this figure are intended to be inclusive of those most likely to be encountered, but this listing is by no means comprehensive. Following is a brief description of each of these warnings. A thorough discussion of these warnings is provided in Module 2.

- Security Breach. Physical security breaches, such as unsecured doors, open hatches, and unlocked/forced gates, are probably the most common threat warnings. In **most** cases, the security breach is likely related to lax operations or typical criminal activity such as trespassing, vandalism, and theft rather than intentional contamination of the water. However, it may be prudent to assess any security breach with respect to the possibility of contamination.

- Witness Account. Awareness of an incident may be triggered by a witness account of suspicious activity, such as trespassing, breaking and entering, and other types of tampering. Utilities should be aware that individuals observing suspicious behavior near drinking water facilities will likely call 911 and not the water utility. In this case, the incident warning technically might come from law enforcement, as described below. Note: the witness may be a utility employee engaged in their normal duties.

- Direct Notification by Perpetrator. A threat may be made directly to the water utility, either verbally or in writing. Historical incidents would indicate that verbal threats made over the phone are more likely than written threats. While the notification may be a hoax, threatening a drinking water system may be a crime under the Safe Drinking Water Act as amended by the *Bioterrorism Act*, and should be taken seriously.

- Notification by Law Enforcement. A utility may receive notification about a contamination threat directly from law enforcement, including local, county, state, or federal agencies. As discussed previously, such a threat could be a result of suspicious activity reported to law enforcement, either by a perpetrator, a witness, or the news media. Other information, gathered through intelligence or informants, could also lead law enforcement to conclude that there may be a threat to the water supply. While law enforcement will have the lead in the criminal investigation, the utility has primary

responsibility for the safety of the water supply and public health. Thus, the utility's role will likely be to help law enforcement to appreciate the public health implications of a particular threat as well as the technical feasibility of carrying out a particular threat.

- Notification by News Media. A threat to contaminate the water supply might be delivered to the news media, or the media may discover a threat. A conscientious reporter would immediately report such a threat to the police, and either the reporter or the police would immediately contact the water utility. This level of professionalism would provide an opportunity for the utility to work with the media and law enforcement to assess the credibility of the threat before any broader notification is made.

- Unusual Water Quality Parameters. The relationship between contamination and changes in water quality parameters is not well understood. However, it is appropriate to investigate the cause of unusual changes in water quality parameters. For water systems, changes in water quality parameters, such as pH, chlorine residual, turbidity, etc. may be detected through the use of either on-line monitors or grab samples. In utility operations, this data may arise from several sources: samples collected for plant operations, routine baseline monitoring programs (Section 4.9), and monitoring systems designed to provide early warning of changes in water quality (Section 6.2). The results of these approaches may be used to warn of a threat. However, as discussed in Sections 4.9 and 4.10, it is vital to consider the reliability of the results from the particular detection method or on-line monitoring system (i.e., false positives/false negatives, known interferences, instrument reliability, and unusual water quality conditions associated with a known cause, such as overdosing of coagulant).

- Consumer Complaint. An unexplained or unusually high incidence of consumer complaints about the aesthetic qualities of drinking water may indicate potential contamination. Many chemicals can impart a strong odor or taste to water, and some may discolor the water. Taste and odor complaints are quite common for water utilities, but unique taste and odor problems, particularly very unusual tastes and odor complaints clustered in a geographical area, may indicate additional problems.

- Public Health Notification. In this case, the first indication that contamination has occurred is the appearance of victims in local emergency rooms and health clinics. Utilities may therefore be notified, particularly if the cause is unknown or linked to water. An incident triggered by a public health notification is unique in that at least a segment of the population has been exposed to a harmful substance. If this agent is a chemical (including biotoxins), then the time between exposure and onset of symptoms may be on the order of hours, and thus there is the potential that the contaminant is still present. On the other hand, the incubation period for most pathogens is on the order of days to weeks; thus, the pathogen may have moved through the distribution system and may therefore be below detectable limits, or present only in trace quantities.

3 How should I Respond to Water Contamination Threats?

This section is not designed to discuss what specific steps to take in responding to a contamination threat. Various "What to do?" steps in the response process will be discussed in Section 4 and associated modules. Rather, the questions addressed in this section are "Why is it necessary to respond to contamination threats at all?" and "When have I done enough?"

3.1 I'm Just a Utility—Why Do I Need to do Anything at All?

As discussed in Section 2, it is technically possible to introduce a contaminant into a public water supply, and historical evidence suggests that the threat of contamination is indeed probable. Regardless of whether contamination is actual or threatened, both deeply impact the public health mission of water utilities. Water utilities play an essential role in providing safe and reliable drinking water supplies, preventing many problems and diseasees that flourish in the absence of safe water programs. Most water utilities take their public health mission very seriously, and some are proactive in developing their plans to respond to water contamination threats. They do this often because they realize that planning for contamination events may also be beneficial in developing a more effective response to other types of emergencies.

Proper planning is a delicate process because public health measures are rarely noticed or appreciated except when they fail. Consumers are particularly upset by unsafe water because safe drinking water is often viewed as an entitlement, and indeed, it is reasonable for consumers to expect a high quality product. Public health failures during response to contamination threats often take the form of too **much** or too **little** action. The results of too little action, including no response at all, can have disastrous consequences potentially resulting in public disease or fatalities. On the other hand, a disproportionate response to contamination threats that have not been corroborated (i.e., determined to be 'credible') can also have serious repercussions when otherwise safe water is unavailable. Not only would the water be unavailable for human consumption, but it would also be unavailable for sanitation, firefighting, industry, and the many other uses of public water supply. These adverse impacts must be considered when evaluating response options to a contamination threat.

Considering the potential risks of an inappropriate response to a contamination threat, it is clear that a systematic approach is needed to evaluate contamination threats. This systematic approach is developed throughout the RPTB. One overriding question is "When has a drinking water utility done enough?" This question may be particularly difficult to address when considering the wide range of agencies that may be involved in a threat situation. Other organizations, such as EPA, CDC, law enforcement agencies, health departments, etc., will each have unique obligations or interests in responding to a contamination threat.

3.2 Due Diligence—When Have I Done Enough?

The guiding principle for responding to contamination threats is one of 'due diligence' or "what is a suitable and sensible response to a contamination threat?" As discussed above, some response to contamination threats is warranted due to the public health implications of an actual contamination incident. However, a utility could spend a lot of time and money over-responding

to every contamination threat, which would be an ineffective use of resources. Furthermore, over-response to a contamination threat carries its own adverse impacts.

Ultimately, the answer to the question of 'due diligence' must be decided at the local level and will depend on a number of considerations. Among other factors, local authorities must decide what level of risk is reasonable in the context of a perceived threat. Careful planning is essential to developing an appropriate response to contamination threats, and in fact, one primary objective of the RPTB is to aid users in the development of their own site-specific plans that are consistent with the needs and responsibilities of the user. Beyond planning, the RPTB considers a careful evaluation of any contamination threat, and an appropriate response based on the evaluation, to be the most important element of due diligence.

Figure 1-2 provides an overview of the response process presented in the RPTB that illustrates (through the two expanding vertical arrows) that response actions escalate as the credibility of a threat increases. In the RPTB, the threat management process is considered in three successive stages: *'possible'*, *'credible'*, and *'confirmed'*. Thus, as the threat escalates through these three stages, the actions that might be considered due diligence expand accordingly. The following paragraphs describe, in general terms, actions that might be considered as due diligence at these various stages. Module 2 describes the evaluation of these stages, and associated response actions that might be considered at each stage.

- Stage 1: "Is the threat possible?" If a utility is faced with a contamination threat, they should evaluate the available information to determine whether or not the threat is 'possible' (i.e., could something have actually happened). If the threat is 'possible,' *immediate operational response* actions might be implemented, and activities such as *site characterization* would be initiated to collect additional information to support the next stage of the threat evaluation.

- Stage 2: "Is the threat credible?" Once a threat is considered 'possible,' additional information will be necessary to determine if the threat is 'credible.' The threshold at the credible stage is higher than that at the possible stage, and in general there must be information to corroborate the threat in order for it to be considered 'credible.' Given the higher threshold at this stage, more significant response actions might be considered, such as restrictions on public use of the water (e.g., issuance of a 'do not drink' notice). Furthermore, steps should be initiated to confirm the incident and positively identify the contaminant.

- Stage 3: "Has the incident been confirmed?" Confirmation implies that definitive evidence and information have been collected to establish the presence of a harmful contaminant in the drinking water. Obviously, at this stage the concept of due diligence takes on a whole new meaning since authorities are now faced with a potential public health crisis. Response actions at this point include all steps necessary to protect public health, to supply the public with an alternate source of drinking water, and to begin remediation of the system.

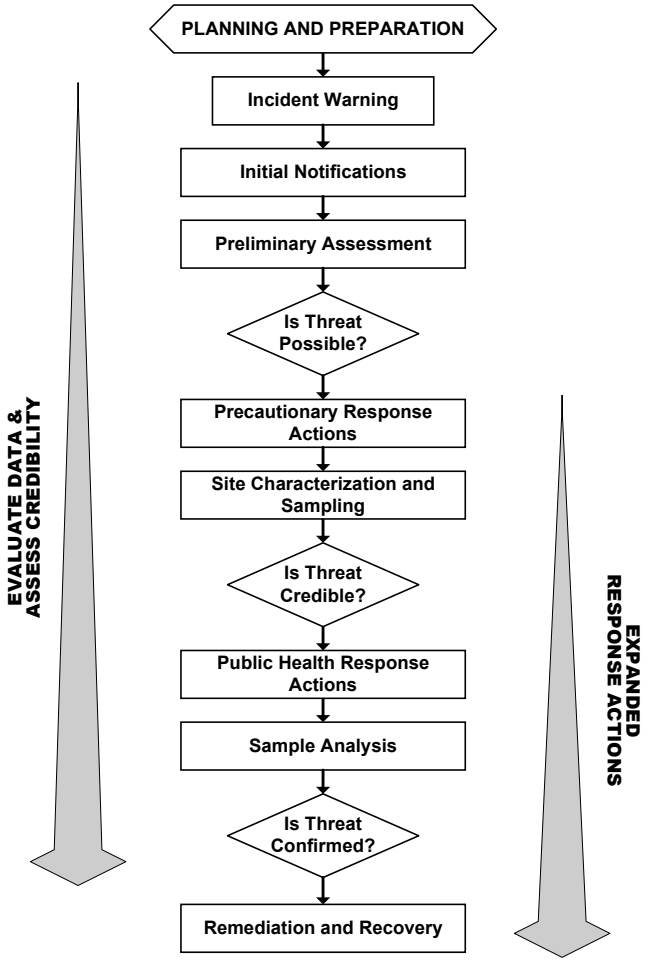


Figure 1-2. Overview of Response to a Contamination Threat

If the process outlined in Figure 1-2 is followed as far as the situation warrants, and the responsible parties use it as a guide in making appropriate response decisions, then they may be viewed as exercising 'due diligence.' All the modules of the RPTB contain in-depth information about the application of the process. In particular, Module 2 describes threat management and the three stages of the threat evaluation in great detail. **The application of this process to a specific contamination threat will vary significantly with the circumstances of the threat.** In summary, judgment must be exercised when determining how to appropriately manage a specific contamination threat. Tabletop exercises, described below in Section 4.7, may provide valuable practice in this regard.

4 What Can I do to Prepare?

One of the steps that utilities can take to prepare for contamination threats is to **read relevant modules of the "Response Protocol Toolbox" and use the information contained within to develop their own specific Response Guidelines and updated Emergency Response Plans!** Specific planning and preparation activities are summarized in the following subsections.

4.1 Know your Water System

4.1.1 Construction and Operation

Each water system is unique with respect to age, operation, and complexity. Distribution systems are particularly unique in that many are a complex, and often undocumented, mix of relatively new and old components. Accordingly, understanding a distribution system as it relates to water security and response planning may be an equally complex task. Despite the challenges to understanding a water supply system, the benefits of doing so could include effectively managing threats and preventing the spread of potentially contaminated water. For instance, the water system may have structural features that enable effective isolation of a contaminated area. Also, it may be readily apparent from knowledge of system vulnerabilities that it would be very easy to introduce a contaminant at a particular location.

There are many ways to gain a better understanding of a particular water system, one of which is through a *vulnerability assessment*. Perpetrators who intentionally contaminate water may seek to produce an adverse consequence through exploitation of vulnerabilities. All drinking water plants are, to some degree, vulnerable to intentional contamination incidents. The nature and extent of these vulnerabilities depends on a number of factors such as source water type, treatment plant type, type of primary disinfectant used, residual disinfectant used in the distribution system, and security measures already in place. An assessment of the drinking water plant and system may help to identify key locations that are vulnerable to intentional contamination, or the availability of opportunity contaminants that might be prevalent in the area. Better understanding the vulnerabilities of a water system provide a basis for improving physical security against intentional contamination and preparing for the evaluation of contamination threats. Accordingly, the Bioterrorism Act established requirements that community water systems serving more than 3,300 individuals perform a system specific vulnerability assessment for potential terrorist threats, including intentional contamination (http://www.epa.gov/safewater/security/community.html).

Another aspect of the water system that may be important, particularly in evaluating the potential spread of a suspected contaminant, is its hydraulic configuration and operation. Propagation of a contaminant through a system is dependent on a number of factors, including: mixing conditions at the point of contamination, hydraulic conditions within the system at the time of the contaminant introduction, and reactions between the contaminant and other materials in the system. There are several techniques for understanding the hydraulics of a water supply system. As discussed more completely in Module 2, Section 2.3.1, developing this understanding may be as complex as utilizing a GIS system in conjunction with a hydraulic modeling program or as simple as manually mapping the pressure and flow zones within a system.

Information about construction materials used in the system may be contained within the utility records and can be useful in evaluating the fate and transport of a particular contaminant through a system. For example, a particular contaminant may adsorb to the pipe material used in a utility's distribution system, and this type of information would be critical in evaluating remediation options following a contamination incident (see Module 6).

4.1.2 Personnel

The employees of a water utility are generally its most valuable asset in preparing for and responding to water contamination threats and incidents. They have knowledge of the system and water quality, and may also have experience in dealing with previous contamination threats. The importance of knowledgeable and experienced personnel is highlighted by the complexity of most water treatment and distribution systems. This complexity makes a successful contamination of a specific target contingent upon detailed knowledge of the system configuration, hydraulic conditions, usage patterns, and water quality. If perpetrators have somehow gained a sophisticated understanding of a water supply system, the day-to-day experience of water system personnel will prove an invaluable tool to countering any attacks. For instance, personnel may continually look for unusual aspects of daily operation that might be interpreted as a potential threat warning, and may also be aware of specific characteristics of the system that make it vulnerable to contamination.

4.1.3 Customers

Knowledge of water system customers is an important component of preventing and managing contamination incidents. Prevention is based largely on understanding potential targets of contamination. Of special concern may be hospitals, schools, government buildings, or other institutions where large numbers of people could be directly or indirectly affected by a contamination threat or incident. Steps taken to protect the drinking water supply for these critical customers, such as enhancements to the physical security of distribution system elements at these locations, may deter the attack itself.

Water customers vary significantly with regard to their expectations of what constitutes acceptable water service, so it is necessary to consider the manner in which water is used in a particular system. For example, high water demand that is largely driven by industry has different implications compared to high usage rates in an urban center with a high population density. Some customers, such as hospitals and nursing homes, may have certain water quality requirements. Sensitive sub-populations, including children and the elderly, can exhibit adverse health effects at doses more than an order of magnitude lower than those necessary to produce disease or death in a healthy adult. That being said, for the purposes of managing water contamination threats, it is important to keep in mind that the most important goal is protecting the health of the public as a whole. Planning, preparation, and allocation of resources should be directed toward protecting the public at large, beyond specific demographic groups or individual users.

4.2 Update Emergency Response Plans for Intentional Contamination

Emergency response plans (ERPs) are nothing new to water utilities, since many have developed ERPs to deal with natural disasters, accidents, civil unrest, etc. Because water utilities are a vital part of the community, it has been prudent for many utilities to develop these in order to help ensure the continuous flow of water to the community. However, many water utility ERPs developed prior to 9/11 do not explicitly deal with terrorist threats, such as intentional contamination. Recently, the U.S. Congress required community water systems serving a population greater than 3,300 to prepare or revise, as necessary, an ERP to reflect the findings of their vulnerability assessment and to address terrorist threats (http://www.epa.gov/safewater/security/community.html).

In response to the legal mandate to revise ERPs, there is an increased demand for guidance that addresses terrorist threats to water supply systems. The U.S. EPA is preparing this guidance, which will be published in a separate document (U.S. EPA, 2003b, "Drinking Water Model Emergency Response Plan," in development. See also U.S. EPA, 2003c, "Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002). For those existing plans that can be revised, information contained in this RPTB may help utilities to address the contamination threat in their revised ERPs, although it should be noted that there is no regulatory requirement to use the RPTB in this manner. However, the RPTB does provide a framework that will aid utilities in planning an effective response to contamination threats, which might be considered during revision to their ERP.

4.3 Develop Response Guidelines for Intentional Contamination

Although not a formal part of an ERP, utilities may wish to develop *Response Guidelines* (RGs) for managing contamination threats. RGs are different from ERPs in that they are essentially a "field guide" for responding to contamination threats. RGs may be developed in many different formats, but a core feature of any RG is that it is easy to use in the field and under crisis conditions. Because RGs are used in the field, they should be action-oriented, easy to follow, and contain all the necessary forms and information. For instance, they should contain forms to document observations at the site of a suspected contamination incident and to log samples collected from the site. Additionally, the guidelines might include flow charts depicting the steps of a process, simple reference tables, and other information that can easily be used during the intense period of an initial response to a threat. A trained individual should be able to follow a well organized RG with minimal difficulty. While the RPTB is not set up in the streamlined format of an effective set of RGs, the material contained in the RPTB can certainly support the development of guidelines, and an example outline for a set of RGs is included in Appendix 5.1 of this Module. The outline may be filled using model text, figures, and forms contained in the various modules of the RPTB, in addition to the users' own materials.

4.4 Establish Structure for Incident Command

One of the primary reasons that ERPs and RGs fail (for any type of emergency, not just water contamination) is that there is no clear leader established by the plan. Thus, in planning for a water emergency, it is important to establish a command structure. This involves establishing a

chain of command, identifying key individuals, and clearly defining their roles and responsibilities, so that they may effectively manage the emergency situation. This section describes an incident command structure based on the *Incident Command System (ICS)*. See http://training.fema.gov/EMIWeb/IS/is195.asp for ICS training material produced by FEMA.

In summary, ICS is the model tool for command, control, and coordination of a response to a public crisis. The tool provides a means to coordinate the efforts of individual agencies as they work toward the common goal of stabilizing the incident and protecting life, property, and the environment. The rationale is that large-scale disasters may be multi-jurisdictional and require cooperation among several agencies. Furthermore, ICS is used by many local, state and federal response agencies and is part of the National Interagency Incident Management System (NIIMS). Note that NIIMS is different than the National Incident Management System (NIMS), which is under development for use by the National Response Plan (see Appendix 6.2 of this Module).

Federal law requires hazardous materials (HazMat) responders to use ICS, and many States are adopting ICS as their standard for responding to all types of incidents. However, in the 'possible' stage of the evaluation of a water contamination threat, HazMat will probably not be involved, and the mandated ICS may not be applied. Rather, the utility, or possibly a technical assistance provider such as a state drinking water primacy agency, would manage the threat. However, at some point following the determination that a contamination threat is 'credible,' the existing ICS at the local or State level would likely be implemented. For major disasters and emergencies, including terrorist acts, the Federal Response Plan (see Appendix 6.3 of this Module) provides the mechanism for federal departments and agencies to coordinate delivery of Federal assistance and resources to augment efforts of overwhelmed local and State governments. Fortunately, one of the benefits of ICS is its ability to expand and contract based on the needs of the situation. Thus, to make potential expansion as seamless as possible, it seems logical that utilities adopt ICS conventions during their response to a contamination threat, even during the 'possible' stage, to facilitate coordination between the utility and other responding agencies that may become involved at a later stage.

Figure 1-3 (left) provides a schematic of ICS for a water utility during a 'possible' threat, in which utility staff have primary responsibility for managing the threat (see Module 2, Section 3). It is anticipated that during this initial stage, the water utility staff will conduct the threat evaluation (Figure 1-3, top middle). At some point during the response to a 'credible' threat, various responding agencies would be organized under ICS according to the principle of *unified command*, and the IC might be someone from an outside organization such as FBI or the State/local health department (Figure 1-3, bottom middle). Unified command is a team effort which allows all agencies with responsibility for the incident, either geographic or functional, to manage an incident by establishing a common set of incident objectives and strategies. This is accomplished without abdicating agency authority, responsibility, or accountability. When command is transferred, it is anticipated that water utility staff will continue to occupy roles in the command structure, but this is at the discretion of the new incident commander. Figure 1-2 (right) is an example of unified command under ICS that might be assembled to respond to a 'confirmed' water contamination incident. For 'confirmed' incidents, it is assumed that an agency external to the water utility has assumed responsibility for incident command. However,

the utility will still have a role in this incident command structure since they are responsible for the operation and maintenance of the drinking water system.

Figure 1-3 is primarily intended to illustrate the expanding nature of the incident, show model ICS structures, and point out the changing role of the water utility in the command structure. It must be customized for a particular situation, and should be expanded and contracted as necessary. Regardless of the size and shape, the command structure operates most efficiently if each person in an organization reports only to one designated individual, a concept known as *unity of command*. Likewise, communication outside of the command structure should be made only through designated individuals (i.e., information officers, liaison officers, or points of contact). Following are some definitions used in Figure 1-3.

1. *Incident commander* (IC): The IC sets incident objectives and priorities, and has overall responsibility for management of the incident. Thus, for water contamination, the incident commander coordinates all the activities involved, whether they are related to the water utility, local civil defense, public health, public works, etc. One key role of incident command is to effectively communicate with all participants involved in the management of the incident, including those outside of the water utility's own command structure. Various individuals may assume the role of incident commander depending on the stage of the response. In ICS, the initial incident commander is traditionally defined as the senior first-responder to arrive at the scene. However, due to the nature of water contamination events triggered by the warnings described above, it is likely that there will need to be a designated individual at the water utility who becomes the incident commander when a threat is reported. This individual is known as the water utility emergency response manager (WUERM).

2. *Water Utility Emergency Response Manager* (WUERM): The WUERM is an individual (or several individuals) with designated responsibility for managing the utility's response to a contamination threat or incident. As discussed above, the WUERM will likely serve as IC during the early stages of the response. Given this responsibility, the WUERM should be empowered to make decisions regarding the threat evaluation (i.e., determining whether or not a threat is 'possible') and response decisions in the early stages of the threat management process. Should the threat rise to an appropriate level, the WUERM may recommend that the *emergency operations center* (EOC) be activated. Once the threat or incident rises to a level such that responsibility for incident command is transferred to another organization, the WUERM will still have a significant role in the response, and will likely serve as the utility's representative in the ICS structure.

3. *Water Utility Emergency Operations Center Manager* (WUOCM): The WUOCM is an 'emergency manager' who heads the water utility's EOC, which is responsible for operational and resource management during an emergency. The general position of 'emergency manager' is described in FEMA's training documents, http://training.fema.gov/EMIWeb/IS/is1.asp, although specific duties for water utilities may differ. In most cases, responsibilities of the WUOCM and the WUERM will fall upon different individuals.

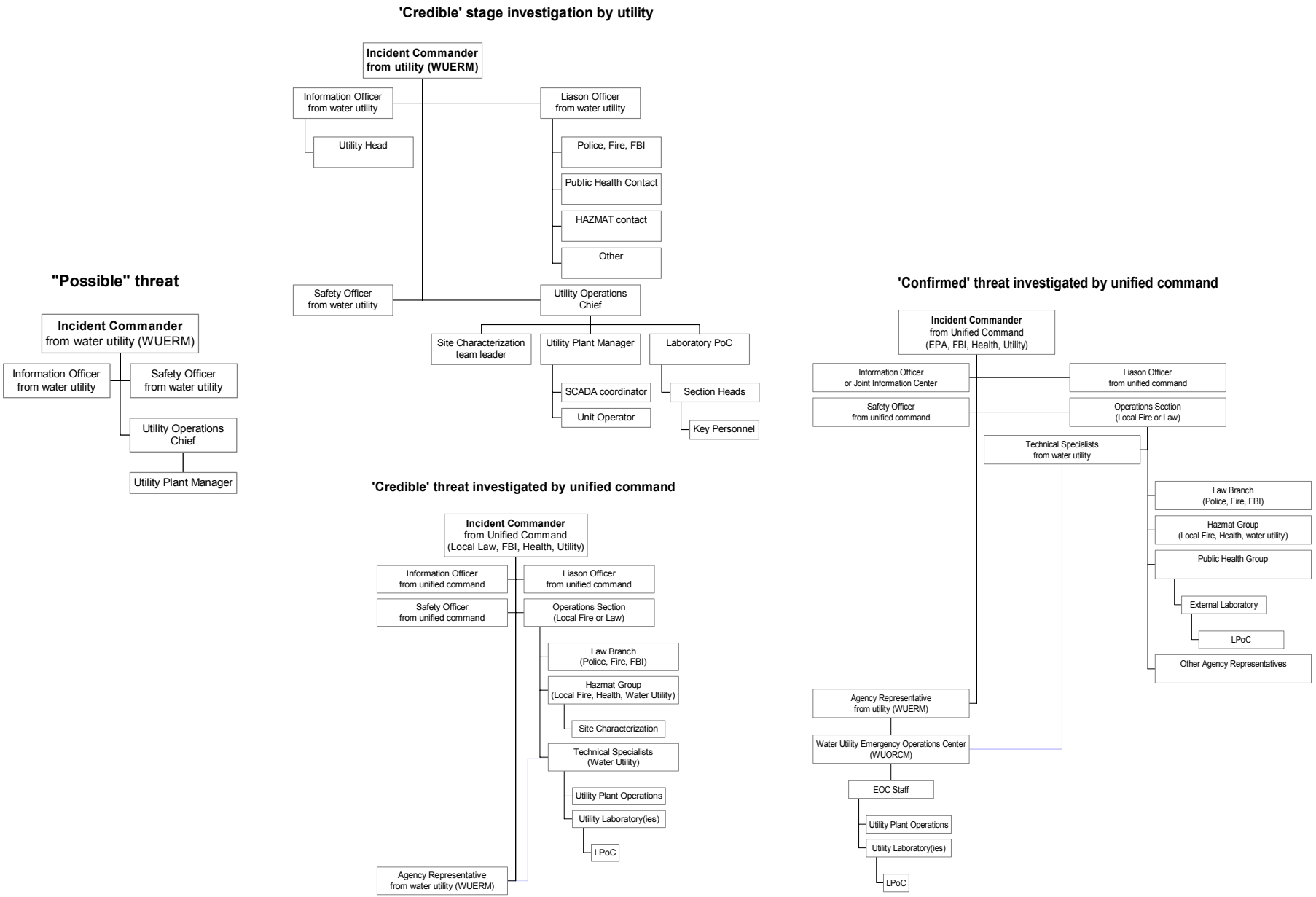


Figure 1-3. Expansion of, and Changes to, Incident Command Structure for the Three Threat Evaluation Stages

4. *Information Officer (IO)*: The IO is part of the command staff and reports directly to the IC. The IO is responsible for planning the information strategy, discussed in Section 4.5 below. Another very important role of the IO is interfacing with the media and disseminating public information.

5. *Liaison Officer (LO)*: The LO is part of the command staff and is the on-scene contact for representatives from other agencies assisting with the incident.

6. *Laboratory Point of Contact (LPoC)*: The LPoC is the designated person at the laboratory with whom the WUERM (or IC) communicates. The LPoC coordinates analytical activities with the WUERM (or IC) and reports analytical results only to the WUERM (or IC).

7. *Safety Officer*: The Safety Officer's function is to develop and recommend measures for assuring personnel safety, and to assess and/or anticipate hazardous and unsafe situations. Only one Safety Officer should be assigned per incident. The Safety Officer may have assistants as necessary, and the assistants may also represent assisting agencies or jurisdictions. Safety assistants may have specific responsibilities such as air operations, hazardous materials, etc.

8. *Agency Representatives*: In many *multi-jurisdiction incidents*, an agency or jurisdiction will send a representative to assist in coordination efforts. An Agency Representative is an individual assigned to an incident from an *assisting agency* or *cooperating agency* who has been delegated authority to make decisions on matters affecting that agency's participation at the incident. Agency Representatives report to the Liaison Officer, or to the Incident Commander in the absence of a Liaison Officer. As illustrated in Figure 1-3, if the WUERM is not the incident commander, then the WUERM may be the agency representative for the drinking water utility in the ICS.

9. *Technical Specialists*: Certain incidents or events may require the use of Technical Specialists who have a specialized knowledge and expertise. As illustrated in Figure 1-3, Technical Specialists may be assigned to any aspect of the response where their services are required. Because water utility staff have intimate knowledge of their own system, there role in this position will be invaluable during every stage of the response.

The identity of the WUERM, WUOCM, IO, LO, LPoC, and other designated individuals should be determined locally, based on the utility's size, needs, and responsibilities. Large systems may need to designate multiple WUERMs such that one is always available. Small utilities and small communities may have an abbreviated version of command structure. In this case, the WUERM, WOURC, IO, LO, and other designation individuals could be the same person, or some of these positions may be filled by individuals outside of the utility (e.g., from local government). For the case of the small utility, it may greatly enhance the response process if the particular individual understands ICS, because the small utility may need to coordinate with a larger, better resourced organization, like a state or federal entity. Also, in small systems, the WUERM will likely need to engage other decision officials at the state or local level earlier in the process than will the WUERM at large utilities.

4.5 Develop Information Management Strategy

As described previously, the role of the IO is to manage the large amount of information that might be used during the threat evaluation process and to support decisions about various response actions. For instance, Module 2 describes a number of information resources that may be of use during the threat evaluation process, but only if the information has been properly managed and is readily accessible. Thus, provisions should be made to readily access this information.

Crisis Information Management Software (CIMS) may be useful, especially when interfaced with a central data repository and/or electronic data management system. A description and comparison of several commercial CIMS packages has been prepared by the Department of Justice (DOJ, http://www.ncjrs.org/pdffiles1/nij/197065.pdf). A Field Operations and Records Management System (FORMS), originally developed for EPA's Contract Laboratory Program, may also help manage records relevant to sample documentation, analysis, and tracking during evaluation of water threats (http://www.epa.gov/superfund/programs/clp/f2lite.htm).

Another component of information management is planning for the flow of information during the response to a threat or incident. The individuals or agencies responsible for receipt and management of information are related to the communication strategy described in the next section. However, as part of the information management strategy, a plan must be developed for the flow of information to appropriate individuals within the ICS structure. The release of inaccurate information at an inappropriate time can have severe consequences for the response, criminal investigation, and well-being of the public.

The proper flow of communications during a crisis can be facilitated through the establishment of a Joint Information Center (JIC), a structure that works within the framework of ICS (See http://www.nrt.org/production/nrt/home.nsf/Resources/publications/$FILE/JIC.pdf for a JIC model). This model documents a plan for conducting crisis communications during response to emergencies in which multiple organizations need to collaborate to provide timely, useful, and accurate information to the public and other stakeholders. The model was designed based on requirements identified by the National Response Team (http://www.nrt.org). Although the model was not developed expressly for water utilities, some of the criteria used in the model's development are appropriate for a water utility's information management strategy. Because it is designed on the basis of function, the model can be used during any situation in which there is a need for centralized communications support involving multiple organizations.

It is important to highlight the IO's responsibility as a contact for the media and public. In this manner, the media and public receive information from a single source, which may help eliminate the confusion inherent to an emergency situation. It is important for the media and public to understand that the IO is the only official source of information about the emergency, and that they are receiving information from a consistent source. For this reason, it may be desirable that the IO remains the same even if the incident commander changes, as may be the case for incidents that reach the 'confirmed' stage (see Figure 1-3).

4.6 Establish Communication and Notification Strategy

The ICS requires communication strategies be planned and made available to all potential participants prior to an actual incident or threat. For the purposes of responding to a water contamination threat, the ICS structure illustrated in Figure 1-3 indicates there could be several management levels within the utility, as well as external to the utility, that may be involved in the management of a contamination threat. The hierarchy of potential participants includes: the utility, local government, the regional government (e.g., county), state government, and federal government. Not all of these levels would necessarily be involved in every situation; however, the mechanism and process through which they interact must be decided in advance of an incident to achieve optimal public health and environmental protection. Due to the number and variety of possible participants, **planning for effective communication is critical.** ICS employs two main strategies to ensure effective communication. The first is the use of common terminology, and the second is unity of command.

Regardless of the strategy employed within the ICS, developing the plan requires a significant level of effort. An effective communication plan is more than just the telephone directory of utility employees and external contacts, although such a directory is often beneficial. Rather, planning communications involves developing a notification hierarchy for reporting threat warnings and other critical information to appropriate individuals at each stage of the response. Many of the individuals that would need to be notified at key points in the response are identified in the ICS, but others may be outside the ICS chain of command. For example, the head of the utility or the drinking water primacy agency may wish to be notified in the case of any threat, although neither may be in the ICS chain of command. However, in general, communications should proceed along the chain of command of the ICS. The number of people notified will increase as the incident expands and decreases as it contracts toward its conclusion. The exact persons notified will be at the discretion of the IC with interaction with the IO, and should be planned in advance. Local requirements may influence the required communication at the various stages.

Figure 1-4 is designed to illustrate the expanding nature of notifications as the threat evaluation proceeds through the 'possible,' 'credible,' and 'confirmed' stages. Figure 1-4 is primarily intended to show the utility's role in the communications, which is based on the ICS structure shown in Figure 1-4. Accordingly, the communications depicted in Figure 1-4 are only those parts of Figure 1-3 in which the utility is involved. The three stages in Figure 1-4 illustrate a possible structure of the communication hierarchy upon expansion but does not necessarily define the exact path or circumstances under which expansion will occur as a threat escalates. Careful planning and thoughtful actions during the management of the threat will dictate how this expansion will occur. Figure 1-4 shows an example notification hierarchy for each stage of the threat management process, and in the situation in which the credibility determination is made by the utility and the credibility determination is made by an external organization. Utilities should plan communication schemes for both of these cases because, although the role of individuals within the ICS may change, the individual involved will not.

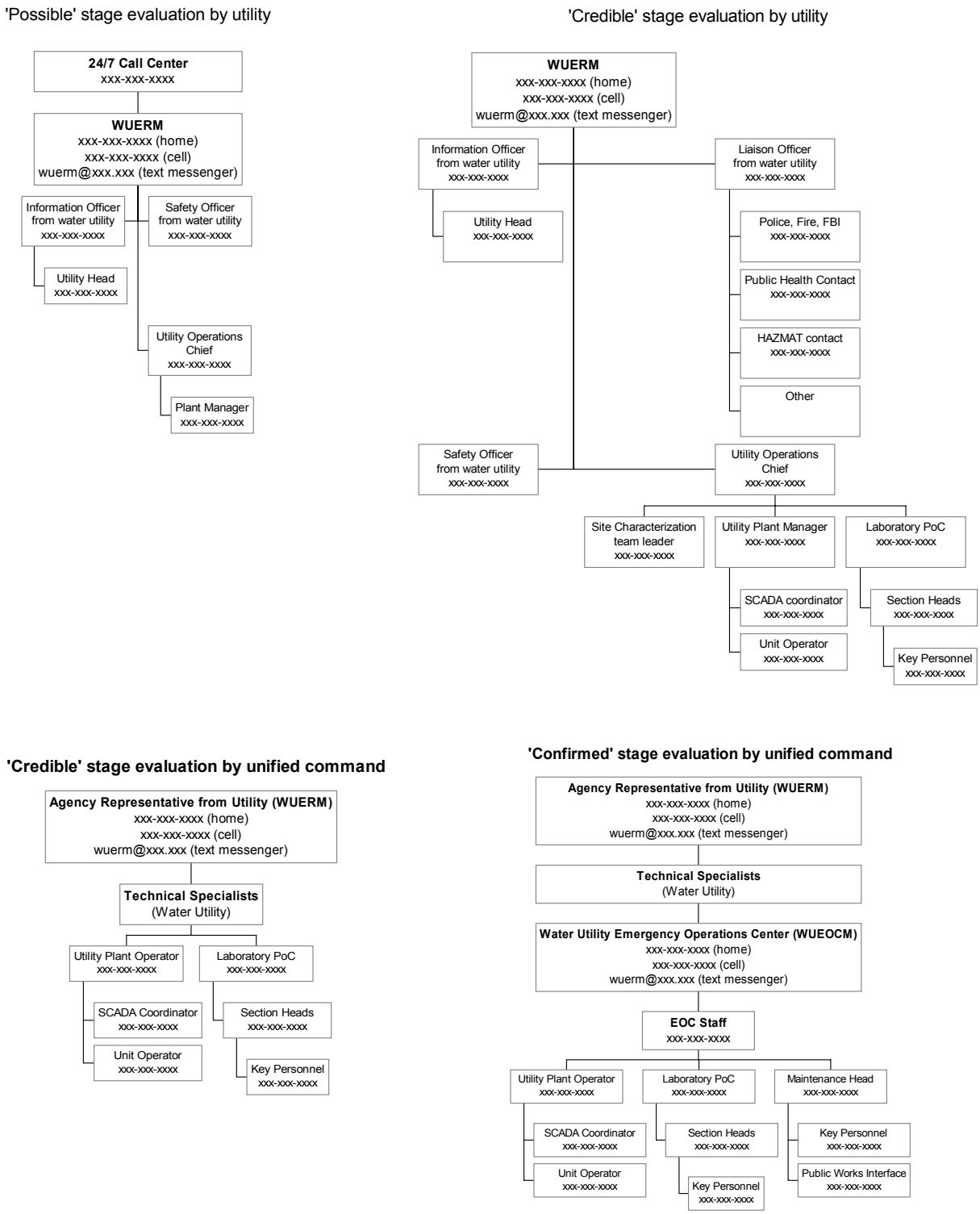


Figure 1-4. Sample Communication Schemes for the Three Threat Evaluation Stages

For the 'possible' stage (Figure 1-4, top left), most of the communications and notifications are internal and begin with the WUERM being notified about the threat. However, depending on the nature of the threat warning, it may be necessary to notify external agencies at the 'possible' stage (e.g., notification of law enforcement in the case of a direct threat from a perpetrator). Utilities must establish some mechanism for informing the WUERM of the incident. A 24/7 operations center may be effective for this purpose. The scale and staffing of an operations center will vary substantially with utility. For example, a large utility may have a continually staffed center. A smaller utility may provide the WUERM(s) with a cell phone or perhaps leverage other call centers that exist within the local government.

The WUERM is notified first, and then the WUERM may notify the heads of other departments to get their support for the threat evaluation. The WUERM would also continue notification along the management chain to keep them apprised of the situation. As the threat management process expands, it may be necessary to activate the IO to manage communications with the utility's management chain, as well as external parties. This will allow the WUERM to focus on the overall management of the response to the contamination threat.

It is likely that the utility will carry out the initial phases of the threat evaluation at the 'credible' stage. Figure 1-4 (top right) shows a sample communication scheme, based on internal utility staff and also external parties that may be able to provide information and technical assistance relevant to the threat evaluation. Figure 1-5 expands on some of the "other" external parties that the IO or LO in Figure 1-4 (top right) may need to contact. Note that the local entities in this figure may be contacted earlier than those at higher levels of government.

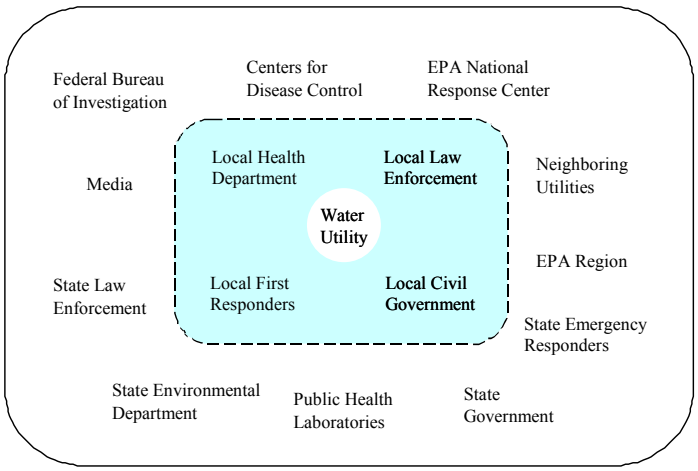


Figure 1-5. Overview of Potential External Notifications

Figure 1-5 does not seek to define a notification scheme or their possible role within the ICS structure – both of these tasks will be incident-specific and/or dictated at the local level. Rather, the figure provides a basic structure for the parties typically involved. These parties are divided into those that are external but still local, and those that are external but at higher levels of government. Notifications by the utility during the threat evaluation at the 'credible' stage

include the drinking water primacy agency (often the State), the emergency response community (including HazMat, EMS, etc.), law enforcement agencies (local, state, and/or federal), government agencies (local, state, and/or federal), the public health community, and external laboratories. Not all of these notifications need to be made in every incident—the overall response plan may dictate what level of notifications should occur and at what stage of the threat evaluation, which in turn dictates who will make the notification. For instance, depending on State requirements, it may not be appropriate for the utility to contact the EPA National Response Center directly. Nevertheless, contact information should be available for all individuals and organizations that may need to be contacted.

If additional support agencies (e.g., HazMat or law enforcement) respond during the 'credible' stage of the threat evaluation, then incident command may be transferred to one of these agencies (Figure 1-4, bottom left). However, staff from the utility's command structure, such as the WUERM, IO and the LO, may still be extremely helpful advisors to the new incident commander; thus, the utility's contact list should be available to unified command. Unified command will handle most communications at this point, so Figure 1-4 (bottom left) only depicts those parts of the ICS structure in which the utility will be involved. The communication strategy represented in Figure 1-4 (bottom left) conforms to Figure 1-3. In this case, more specialized individuals at the water utility become involved as technical specialists, and the WUERM is now acting as the Agency Representative from the water utility. The technical specialists will be a very important part of the ICS, and the utility should plan communication with these individuals carefully.

The 'confirmed' stage pictured in Figure 1-4 (bottom right), represents a significant change in the communication structure because an external agency operating under unified commend will be in charge of the response. Also, the Water Utility Emergency Operations Center (WUEOC) will likely be activated (if it was not already during the 'credible' stage). The chain of communications may proceed through the WUEOC manager (WUEOCM). Technical Specialists that participate in the ICS operated under unified command may also be part of the EOC staff. Additional technical specialists may need to be notified, such as those responsible for repair and maintenance, who would not necessarily be engaged before the incident is confirmed. The role of the utility in overall management and command of the incident may proportionally decrease as many other external parties become involved (see Figure 1-5).

4.7 Perform Training and Desk/Field Exercises

In addition to a lack of planning, another reason that emergency response plans fail is lack of training and practice. Training provides the necessary means for everyone involved to acquire the skills to fulfill their role during an emergency. It may also provide important 'buy-in' to the response process from both management and staff, which is essential to the success of any response plan. Desk exercises (also known as 'tabletops' or 'sand lots') along with field exercises allow participants to practice their skills. Also, these exercises will provide a test of the plan itself, revealing strengths and weakness that may be used to improve the overall plan. Improvements can include measures not only for intentional contamination of water, but also for other emergencies faced by the water utility and the community at large.

Training may be available from EPA or other federal partners. For instance, several online training courses relevant to emergency management are available on-line from FEMA (http://training.fema.gov/EMIWeb/IS/crslist.asp). These courses cover a range of topics including community disaster exercises, emergency manager orientation, and animal health and safety during disasters. Further, it is worthwhile mentioning some areas where formal training is desirable, but not currently available. For example, in addition to training for sampling and site characterization, there are also training needs for a general understanding of the overall threat management process and the ability to make important decisions quickly and with limited information. In the absence of formal training, the reports, forms, templates, SOPs, and checklists that make up a set of RGs may be used as worksheets to practice potential scenarios.

4.8 Enhance Physical Security

Denying physical access to key sites within the water system may act as a deterrent to a perpetrator. Criminals often seek the easiest route of attack, just like a burglar prefers a house with an open window. Aside from deterring actual attacks, enhancing physical security has other benefits. For example, installation of fences and locks may reduce the rate of false alarms. Without surveillance equipment or locks, it may not be possible to determine whether a suspicious individual has actually entered a vulnerable area. The presence of a lock and a determination as to whether it has been cut or broken provides sound, although not definitive, evidence that an intrusion has occurred. Likewise, security cameras can be used to review security breaches and determine if the incident was simply due to trespassing or is a potential contamination threat. The costs of enhancing physical security may be justified by comparison to the cost of responding to just one 'credible' contamination threat involving site characterization and laboratory analysis for potential contaminants.

The correct choice of security enhancements varies by utility, and a number of resources are available to assist in this selection process. For instance, a vulnerability assessment (see Section 4.1.1) may provide a sound basis for making security upgrades. The American Water Works Association has developed a field guide (AWWA, 2002) to help meet security challenges. EPA has developed a series of Security Product Guides to assist treatment plant operators and utility managers in reducing risks from, and providing protection against, possible natural disasters and intentional terrorist attacks (http://www.epa.gov/safewater/security/guide/index.html).

4.9 Establish Baseline Monitoring Program

Background concentrations of suspected or tentatively identified contaminants may be extremely important in determining if a contamination incident has occurred. In some cases, and for some contaminants, background levels may be at detectable concentrations. **If unrecognized, these may be confused with an actual contamination incident.** Baseline occurrence information, discussed more thoroughly in Module 3, Section 3.5, is derived from monitoring data and is used to characterize typical levels of a particular contaminant or water quality parameter. Baseline data may be used for two purposes in the context of emergency water sampling:

- If general water quality parameters, such as pH, chlorine residual, or conductivity, among others, are used as indicators of possible contamination incidents, a baseline must be established such that significant deviations from the baseline can be observed.

- If a specific contaminant is detected in the water, knowledge of typical background levels may be necessary to properly interpret the results.

4.10 Utilize and Understand On-line Monitoring

On-line monitors are a topic of much interest, although there is a significant level of debate regarding their effectiveness as an early warning system (EWS). AWWARF has published a report discussing on-line monitoring for drinking water utilities (AWWARF, 2002), which outlines the cost-benefit analysis for online monitoring. Many of the costs and benefits are based on issues of general water quality, plant operations, and regulatory compliance. One definite benefit is early detection of changes in water quality parameters, such as pH, chlorine residual, and turbidity. Changes in these parameters relate to treatment plant operation, and may also indicate potential water contamination if properly interpreted. For instance, on-line monitoring may help establish typical background levels of the monitored parameters. These established background levels can then be compared with levels recorded during a suspected contamination incident. Another benefit of on-line monitoring for water security is that it can free operators from manual data collection, and facilitate analysis and interpretation of the data for routine as well as security purposes. Such information should be integrated into the information management plan (see Section 4.5).

In summary, the use of on-line monitors may serve to increase the quality of water in general, but there are unanswered questions regarding their applicability as EWSs. Currently, there are efforts underway within EPA and the water industry to attempt to resolve these issues and also to verify that commercially available on-line monitors perform as effectively as their manufacturers claim. Results of this work may be reported in later versions of the RPTB. The results of EPA efforts to verify monitoring technologies can be found at http://www.epa.gov/etv. Because of interest in on-line monitoring systems that are currently available, a discussion of the two main types, conventional systems and EWSs, is included in Appendix 6.2.

5 References and Resources

References and information cited or used to develop this module are listed below. The URLs of several sources are cited throughout the text. These URLs were correct at the time of the preparation of this document. If the document is no longer available at the URL provided, please search the sponsoring organization's Web site or the World Wide Web for alternate sources. A copy of referenced documents may also be provided on the CD version of this module, although readers should consult the referenced URL for the latest version.

AWWA. 2002. Water System Security: A Field Guide, American Water Works Association, Denver, CO.

AWWARF. 2002. Online monitoring for drinking water utilities. Editor, Erika Hargesheimer, AWWA Research Foundation and CRS PROAQUA, American Water Works Association, Denver, CO.

AWWARF. 2003. Actual and Threatened Security Events, AWWARF Project 2810, American Water Works Association, Denver, CO.
http://www.awwarf.org/research/TopicsAndProjects/projectSnapshot.aspx?pn=2810

DHS. 2003a. "Initial National Response Plan"
http://www.dhs.gov/interweb/assetlibrary/Initial_NRP_100903.pdf

FEMA. 2003a. "IS-195 Basic Incident Command System – EMI Independent Study Program"
http://training.fema.gov/EMIWeb/IS/is195.asp

FEMA. 2003b. "Independent Study Course List"
http://training.fema.gov/EMIWeb/IS/crslist.asp

FEMA. 2003c. "Federal Response Plan"
http://www.fema.gov/rrr/frp/

DOJ/NIJ. 2002. "Crisis Information Management Software (CIMS) Feature Comparison Report"
http://www.ncjrs.org/pdffiles1/nij/197065.pdf

WHO. 2001. "Health Aspects of Biological and Chemical Weapons"
http://www.who.int/emc/pdfs/BIOWEAPONS_FULL_TEXT2.pdf

U.S. EPA. 2002. "EPA Community Drinking Water Security Requirements"
http://www.epa.gov/safewater/security/community.html

U.S. EPA. 2003a. "The Safe Drinking Water Act"
http://www.epa.gov/safewater/sdwa/sdwa.html

U.S. EPA. 2003b. Model Emergency Response Plan, in preparation.

U.S. EPA. 2003c. "Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002"
http://www.epa.gov/ogwdw/security/pdfs/erp-long-outline.pdf

U.S. EPA. 2003d. "FORMS II Lite" http://www.epa.gov/superfund/programs/clp/f2lite.htm

U.S. EPA. 2003e. "Security Product Guides"
http://www.epa.gov/safewater/security/guide/index.html

U.S. EPA. 2003f. "Environmental Technology Verification (ETV) Program"
http://www.epa.gov/etv

International Life Sciences Institute Risk Science Institute. (ISLI). 1999. Early Warning Monitoring to Detect Hazardous Events in Water Supplies. ILSI PRESS, Washington, DC.
http://www.ilsi.org/file/EWM.pdf

NRT. 2000. "NRT Joint Information Center Model: Collaborative Communications During Emergency Response"
http://www.nrt.org/production/nrt/home.nsf/Resources/publications/$FILE/JIC.pdf

NRT. 2003. "National Response Team" (2003) http://www.nrt.org

WHO. 2003. "Public health response to biological and chemical weapons: WHO guidance, 2nd edition (Draft, May 2003)" http://www.who.int/csr/delibepidemics/biochemguide/en/index.html

6 Appendices

6.1 Sample Outline of Response Guideline

A Response Guideline is essentially a "field guide" for responding to contamination threats, and may be composed of appropriate figures, forms, templates, text, and checklists, which can be found in Modules 2 through 6. Expanding the outline below with the content from Modules 1-6 (as listed and/or linked within the outline) should result in an essentially complete response guideline. See the table of contents for the modules for exact locations.

EMERGENCY RESPONSE GUIDE OUTLINE

1. Overview of/Introduction to Response Guidelines (Module 1, Section 4.3)
2. Threat Warning Descriptions (Module 1, Section 2.2)
3. Initial Communication and Notifications (Module 1, Section 4.6)
4. Threat Evaluation
    a. Threat Warning Report Forms (Module 2, Appendix 8.3-8.8)
    b. Threat Evaluation Worksheets (Module 2, Appendix 8.2)
5. Site Characterization
    a. Site Characterization Plan Template (Module 3, Appendix 8.1)
    b. Field Testing Results Form (Module 3, Appendix 8.3)
    c. Site Characterization Report Form (Module 3, Appendix 8.2)
    d. Sample Documentation Form (Module 3, Appendix 8.4)
6. Planned Responses
    a. Response Planning Matrix (Module 2, Appendix 8.1)
    b. Action Plan (Module 2, Section 2.4)
    c. Guidelines for Contaminant Containment (Module 5, Section 4)
    d. Contaminant Identification (Module 4)
    e. Treatment, Removal And/or Disposal of Contaminant (Module 6, Section 6)
    f. Public Notification (Module 5, Section 5)
    g. Alternate Domestic Water (Module 6, Section 5)
    h. Fire Flow Supply (Module 6, Section 5)
    i. Expanded Communications (Module 1, Section 4.6)
7. Plan for Return of Water System to Service (Module 6, Section 8)
8. Appendixes
    a. Appendix I: Phone Directories for Notifications (Module 1, Section 4.6)
    b. Appendix II: Drinking Water Advisories (Module 5, Appendices 8.2 – 8.5)

6.2 U.S. Government Response Plans

6.2.1 National Response Plan

The U.S. Department of Homeland Security was tasked by the Homeland Security Presidential Directive 5 (HSPD-5) to develop, submit to the Homeland Security Council, and administer a National Response Plan (NRP). HSPD-5 required the development and publication of an Initial NRP (INRP), which was released on September 30, 2003. Pending the development of the full NRP, the INRP provides an interim implementation of the domestic incident management authorities, roles, and responsibilities of the Secretary of Homeland Security as defined in HSPD-5. It also provides interim guidance on Federal coordinating structures and processes for domestic incident management. The INRP is applicable to domestic incident management in the context of terrorist attacks, major disasters, and other emergencies. A final NRP will eventually replace the INRP. In the interim period, until the full NRP becomes effective, current Federal incident management and emergency response plans remain in effect, except as specifically modified by the INRP. The full text of the INRP is available at http://www.dhs.gov/interweb/assetlibrary/Initial_NRP_100903.pdf and a fact sheet is found at http://www.dhs.gov/dhspublic/interapp/press_release/press_release_0278.xml

INRP represents a significant first step towards an overall goal of integrating the current family of Federal domestic prevention, preparedness, response, and recovery plans into a single all-discipline, all-hazards plan. The INRP will be supported by the National Incident Management System (NIMS), a national system under development that creates standardized incident management processes, protocols, and procedures.

There are five current emergency response plans that are linked by the INRP:

- Federal Response Plan
- U.S. Government Interagency Domestic Terrorism Concept of Operations Plan
- Federal Radiological Emergency Response Plan
- Mass Migration Response Plans
- National Oil and Hazardous Substances Pollution Contingency Plan

Of these, perhaps the Federal Response Plan is most relevant to water contamination, and it is more completely described below in Appendix 6.2.2.

6.2.2 Federal Response Plan

The Federal Response Plan (FRP, http://www.fema.gov/rrr/frp/) provides the mechanism for federal departments and agencies to coordinate delivery of Federal assistance to State and local governments during a major disaster or emergency, including terrorist acts. The FRP supports implementation of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended (42 U.S. Code 5121, et seq.), as well as individual agency statutory authorities. Under the Stafford Act, a State Governor may request the President to declare a major disaster or an emergency if an event is beyond the combined response capabilities of the

State and affected local governments. Only after the President makes a declaration is the FRP used.

As directed by Presidential Decision Directive (PDD)-39, U.S. Policy on Counter-terrorism, and as articulated in the FRP (FEMA, 2003c), the Department of Justice (DOJ) is designated as the lead federal agency for threats or acts of terrorism within U.S. territory. DOJ assigns lead responsibility for "crisis management" to the Federal Bureau of Investigation (FBI), who acts predominantly in a law enforcement capacity. Crisis management refers to the process by which resources needed to apprehend and prosecute perpetrators are identified, acquired and utilized. Within that process, the FBI operates as the on-scene manager for the Federal Government. It is FBI policy that crisis management will involve only those Federal agencies requested by the FBI to provide expert guidance and/or assistance, as described in the PDD-39 Domestic Deployment Guidelines (classified) and the FBI Weapons of Mass Destruction (WMD) Incident Contingency Plan.

FEMA, a branch of the Department of Homeland Security (DHS), supports the lead federal agency for "consequence management" throughout the Federal response, or serves as the lead federal agency when the Attorney General transfers the role to DHS. Consequence management refers to measures to protect public health and safety, restore essential government services, and provide emergency relief to governments, businesses, and individuals affected by the consequences of terrorism. It is DHS policy to use FRP (FEMA, 2003c) structures to coordinate all Federal assistance to State and local governments for consequence management.

The FRP provides more detailed guidance on the post-incident management and responsibilities of various federal departments and agencies (see Terrorism Incident Annex, Section V, FEMA 2003c). In summary, no single agency or organization at the Federal, State, local, or private-sector level possesses the authority and expertise to unilaterally implement remediation and recovery actions. If Federal assistance is provided under the authorities of the Stafford Act, responsibility for specific tasks will be delegated by the lead agency to those entities that possess the skills and resources required for implementing them. Key areas of responsibility that would potentially support water system remediation and recovery efforts are highlighted below:

DOJ/FBI. DOJ delegates the role of lead federal agency (LFA) to the FBI for operational response. The FBI responsibilities potentially supportive of remediation and recovery will include:

- Designating and establishing a Joint Operations Center (JOC) in the field;
- Appointing an FBI On-Scene Commander (OSC) who will convene and chair meetings of operational decision makers representing lead State and local agencies, DHS/FEMA, and other supporting Federal agencies (e.g., EPA);
- Working with DHS to establish and operate a Joint Information Center (JIC) in the field as a focal point for information to the public and media concerning Federal response;
- Issuing and tracking the status of crisis management actions assigned by the FBI; and
- Designating appropriate liaison and advisory personnel to support DHS.

DHS. DHS supports the overall LFA by operating as the lead agency for consequence management until the overall LFA role is transferred to DHS. DHS will:

- Work with the FBI to establish and operate a JIC in the field as the focal point for information to the public and the media concerning the Federal response to the emergency;
- Establish the primary Federal operations centers for consequence management in the field and Washington, DC;
- Appoint a Regional Support Team (RST) Director or Federal Coordinating Officer (FCO) to manage and coordinate the Federal consequence management response in support of State and local governments. In coordination with the FBI, the RST Director or FCO will convene meetings with decision makers to formulate incident action plans, define priorities, review status, resolve conflicts. These meetings may also be used to identify issues that require decisions from higher authorities, and evaluate the need for additional resources. Decision makers present at meetings may include Federal, State, and local emergency management and technical support agencies, as appropriate;
- Issue and track the status of consequence management actions assigned by DHS;
- Designate appropriate liaison and advisory personnel to support the FBI; and
- As needed, provide assets of the National Disaster Medical System and/or the Metropolitan Medical Response System.

HHS. As directed in PDD-39, the Department of Health and Human Services (HHS) will activate technical operations capabilities to support the Federal response to threats or acts of WMD terrorism. HHS may coordinate with individual agencies identified in the HHS Health and Medical Services Support Plan for the Federal Response to Acts of Chemical/Biological (C/B) Terrorism. Coordination efforts will use the structure, relationships, and capabilities described in the HHS plan to support response operations. Note that CDC, and thus the Laboratory Response Network (LRN), is part of HHS. If the HHS plan is implemented:

- The HHS on-scene representative will coordinate the HHS plan response with the DHS;
- The HHS plan response may include consultation, agent identification, epidemiological investigation, hazard detection and reduction, decontamination, public health support, medical support, and pharmaceutical support operations; and
- HHS will issue taskings that draw on funding from the responding HHS plan agencies.

EPA. As directed in PDD-39, the EPA will activate technical operations capabilities to support the Federal response to acts of WMD terrorism. EPA may coordinate with individual agencies identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)[1] to use the structure, relationships, and capabilities of the National Response System as described in the NCP [40 CFR Part 300 subpart B] to support response operations. If the NCP is implemented:

- The Hazardous Materials On-Scene Coordinator under the NCP will coordinate the NCP response with the DHS official (either the RST Director or the FCO), who is responsible under PDD-39 for on-scene coordination of all Federal support to State and local governments; and

[1] Agencies listed in the NCP include: USCG, FEMA, DOD, DOE, USDA, DOC, HHS, DOI, DOJ, DOL, DOT, DOS, NRC, and GSA.

- The NCP response may include threat assessment, consultation, agent identification, hazard detection and reduction, environmental monitoring, decontamination, and long-term site restoration (environmental cleanup) operations.

USACE. Under FRP Emergency Support Function (ESF) #3, Public Works and Engineering Annex, the U.S. Army Corps of Engineers (USACE) serves as the primary agency responsible, in part, for emergency restoration of critical public facilities. Activities can include the temporary restoration of water supplies and emergency contracting to support public health and safety, such as providing for potable water.

State and Local Authorities. State and local authorities maintain initial responsibility for managing domestic incidents. The Federal Government will assist State and local authorities when their resources are overwhelmed or when Federal interests are involved. In those cases, the local or state agencies (e.g., local health department) should work in partnership with the LFA.

Water Utility. The water utility will possess the most detailed first-hand knowledge and technical expertise regarding the configuration and operation of the water source, storage, treatment, and distribution systems. Accordingly, water utility personnel will serve as technical advisors to lead agency personnel responsible for system characterization, remediation, and recovery. If Federal assistance is provided under the authorities of the Stafford Act, responsibility for specific tasks most likely will be delegated to the water utility by DHS/FEMA or EPA (who will support long-term site restoration and environmental cleanup). In addition, the water utility can play a key role in planning for a remedial response to contamination, including evaluating containment options, and ensuring rapid site access and access to operating records, engineering drawings, etc., that may be required by response action personnel.

6.3 On-Line Monitoring Systems

6.3.1 Conventional systems

Conventional on-line monitoring systems are largely designed to measure typical water quality parameters in a near-real or real-time fashion. Examples of these parameters include: temperature, turbidity, particle counts, color, conductivity, total dissolved solids, alkalinity, pH, chlorine residual, specific UV absorbance, TOC, along with a host of inorganic and organic chemicals. In addition, water flow, level, and pressure may be automatically recorded. Many of these systems are designed to meet regulatory goals related to the reduction of turbidity, DBP formation, and other water quality parameters. These systems are often connected to a utility's SCADA and/or GIS system. The water quality parameters accessible through these systems may also have water security applications, specifically by providing a warning of a possible threat, as discussed in Section 2.2. However, interpretation of this data must be performed cautiously, as discussed in Module 2.

6.3.2 Early warning systems

The goal of an early warning system (EWS) is to identify a low probability/high impact contamination incident in a water system allowing sufficient time for an appropriate response that mitigates or eliminates any adverse impact resulting from the incident (ILSI, 1999). Typically, an EWS for water would be designed to detect the introduction of toxic or infectious contaminants that pose a risk to public health. According to the ILSI report, an ideal EWS would 1) be fully automated, 2) have a rapid response time and high sampling rate, 3) provide a specific and sensitive screen for a range of contaminants, 4) have a low occurrence of false positives and negative, 5) be reliable and rugged, 6) be easy to use, and 7) be affordable to install and operate. Although there are many on-line monitoring systems currently being discussed for use as EWSs, currently, an EWS with all of these features does not exist.

Among the technologies currently promoted as potential EWSs are toxicity monitors, which rely on a biological species as a sentinel for the presence of the contaminant. These range from large animals such as fish to various microbial species of algae. Another approach relies on conventional monitors, in which changes in conventional water quality parameters, such as temperature, chlorine residual, color, conductivity, and pH, are used discretely or in a multi-parameter analysis to infer the presence of a contaminant. Ideally, computerized data systems for these detectors may automatically report significant changes in these parameters. It is important to note, however, that the baseline of these parameters needs to be carefully understood, as well as the relationship between changes in the water quality parameters and the presence of specific contaminants.

Implementation of a poorly characterized monitoring technology will result in a false sense of security since there is no assurance that it is capable of meeting the monitoring objectives. In a worst-case scenario, implementation of a poorly characterized system could result in false alarms that undermine the effectiveness of a monitoring program and result in a needless expenditure of resources to follow up on the false positive result.

Before initiating an early warning monitoring program, the objectives of the program should be clearly defined, and a plan should be developed for the interpretation, use, and reporting of monitoring results. It is critical that this plan be developed before there is a need to monitor or respond to a threat warning and that the plan be developed in coordination with the water utility, local and state health departments, emergency response units, and local political leadership. The consequences of improper coordination among authorities or inappropriate responses to monitoring results can be severe. The key is to have these guidelines and procedures in place prior to deployment of the monitoring system.

As part of the monitoring plan, a hierarchy for dissemination of positive monitoring results should be developed, and this notification hierarchy should be consistent with the utility's overarching ERP. This hierarchy should be based on consideration of who needs the information to make public health decisions and at what time the information is needed. Initially, the results might need to be rapidly disseminated to the WUERM, utility management, emergency response personnel, and the State or local health department. These preliminary monitoring results might trigger various response actions, such as a threat evaluation, additional sampling and confirmatory analysis, and immediate operational response actions.

Another consideration is whether or not to communicate to the public information regarding monitoring efforts designed to counter terrorism. On one hand, public support may be necessary to secure funding for such a monitoring effort, and this may bolster public confidence in the water supply. Also, it could be argued that monitoring could serve as a deterrent to potential criminal or terrorist activities. However, the counter argument is that publicizing a monitoring system, or other security measures, may be viewed as a challenge to terrorists and may increase the likelihood of threats, hoaxes, or attacks. Furthermore, it may provide enough information to allow a criminal entity to determine which contaminants are being monitored and to simply use a contaminant that cannot be detected in an attack on a water supply. It has been suggested that efforts taken to counter terrorism and improve security be put into a context of general preparedness for a variety of incidents or emergencies (ILSIRI, 1999). This will allow a utility to communicate efforts that are being taken to ensure continued operation and the safety of the water supply without focusing on any one specific threat, such as intentional contamination through terrorist activity.

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-001
www.epa.gov/safewater/security
December 2003

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

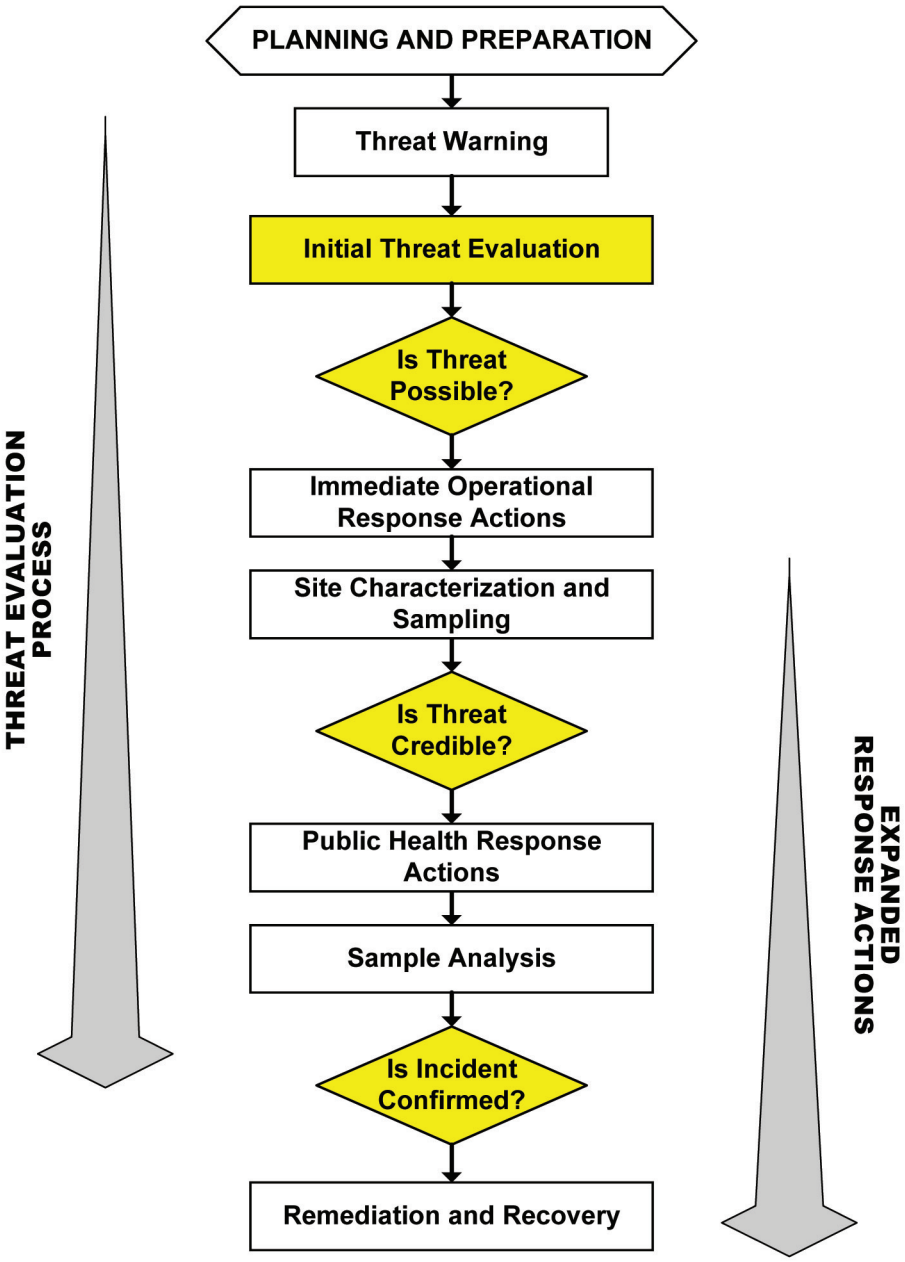
Interim Final - December 2003

Module 2: Contamination Threat Management Guide

Response Protocol Toolbox:
Planning for and Responding to
Drinking Water Contamination Threats and Incidents

Module 2: Contamination Threat Management Guide

Interm Final - December 2003



OTHER RESPONSE PROTOCOL TOOLBOX MODULES

Module 1: Water Utility Planning Guide *(December 2003)*
Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to prepare for response to contamination threats and incidents.

Module 2: Contamination Threat Management Guide *(December 2003)*
Module 2 presents the overarching framework for management of contamination threats to the drinking water supply. The threat management process involves two parallel and interrelated activities: 1) evaluating the threat, and 2) making decisions regarding appropriate actions to take in response to the threat.

Module 3: Site Characterization and Sampling Guide *(December 2003)*
Module 3 describes the site characterization process in which information is gathered from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Module 4: Analytical Guide *(December 2003)*
Module 4 presents an approach to the analysis of samples collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples that may contain an unknown contaminant. The framework is flexible and will allow the approach to be crafted based on the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Module 5: Public Health Response Guide *(available March 2004)*
Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interaction among the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Module 6: Remediation and Recovery Guide *(available March 2004)*
Module 6 describes the planning and implementation of remediation and recovery activities that would be necessary following a confirmed contamination incident. The remediation process involves a sequence of activities including: system characterization; selection of remedy options; provision of an alternate drinking water supply during remediation activities; and monitoring to demonstrate that the system has been remediated. Module 6 describes the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

TABLE OF CONTENTS

1 INTRODUCTION 10

2 OVERVIEW OF THE CONTAMINATION THREAT MANAGEMENT PROCESS 12

2.1 ROLES AND RESPONSIBILITIES 13
2.2 EVALUATION OF WATER CONTAMINATION THREATS 14
2.3 CONSEQUENCE ANALYSIS 16
2.3.1 NUMBER OF INDIVIDUALS AFFECTED 16
2.3.2 HEALTH EFFECTS 17
2.3.3 IMPACTS OF RESPONSE ACTIONS ON CONSUMERS 17
2.4 PLANNING FOR RESPONSE DECISIONS 17

3 'POSSIBLE' STAGE OF THE THREAT MANAGEMENT PROCESS 19

3.1 INFORMATION FROM THE THREAT WARNING 19
3.1.1 SECURITY BREACH 20
3.1.2 WITNESS ACCOUNT 21
3.1.3 DIRECT NOTIFICATION BY PERPETRATOR 22
3.1.4 NOTIFICATION BY NEWS MEDIA 22
3.1.5 NOTIFICATION BY LAW ENFORCEMENT AGENCIES 23
3.1.6 UNUSUAL WATER QUALITY 23
3.1.7 CONSUMER COMPLAINTS 25
3.1.8 NOTIFICATION BY PUBLIC HEALTH AGENCIES 25
3.2 ADDITIONAL INFORMATION CONSIDERED AT THE 'POSSIBLE' STAGE 26
3.2.1 UTILITY INFORMATION AND STAFF KNOWLEDGE 27
3.2.2 VULNERABILITY ASSESSMENT 27
3.2.3 REAL-TIME WATER QUALITY DATA AND CONSUMER COMPLAINTS 28
3.3 RESPONSE ACTIONS CONSIDERED AT THE 'POSSIBLE' STAGE 28
3.3.1 SITE CHARACTERIZATION ACTIVITIES 29
3.3.2 IMMEDIATE OPERATIONAL RESPONSE 32

4 'CREDIBLE' STAGE OF THE THREAT MANAGEMENT PROCESS 35

4.1 INFORMATION CONSIDERED AT THE 'CREDIBLE' STAGE 35
4.1.1 SITE CHARACTERIZATION RESULTS 36
4.1.2 PREVIOUS THREATS AND SECURITY INCIDENTS 37
4.1.3 INFORMATION FROM EXTERNAL SOURCES 38
4.2 RESPONSE ACTIONS CONSIDERED AT THE 'CREDIBLE' STAGE 40
4.2.1 SAMPLE ANALYSIS 41
4.2.2 CONTINUATION OF SITE CHARACTERIZATION ACTIVITIES 43
4.2.3 PUBLIC HEALTH RESPONSE 44

5 'CONFIRMATORY' STAGE OF THE THREAT MANAGEMENT PROCESS 47

5.1 INFORMATION CONSIDERED AT THE 'CONFIRMATORY' STAGE 47
5.1.1 ANALYTICAL RESULTS 48
5.1.2 ADDITIONAL SITE CHARACTERIZATION RESULTS 49
5.1.3 INFORMATION FROM EXTERNAL SOURCES 50
5.2 RESPONSE ACTIONS CONSIDERED AT THE 'CONFIRMATORY' STAGE 51

6 CONTAMINATION THREAT MANAGEMENT MATRICES 54

6.1 SECURITY BREACH 55
6.2 WITNESS ACCOUNT 57
6.3 DIRECT NOTIFICATION BY PERPETRATOR 58
6.4 NOTIFICATION BY LAW ENFORCEMENT 60
6.5 NOTIFICATION BY NEWS MEDIA 62

6.6 UNUSUAL WATER QUALITY 64
6.7 CONSUMER COMPLAINT 66
6.8 PUBLIC HEALTH NOTIFICATION 68

7 REFERENCES AND RESOURCES 70

8 APPENDICES 71

8.1 RESPONSE PLANNING MATRIX 71
8.2 THREAT EVALUATION WORKSHEET 72
8.3 SECURITY INCIDENT REPORT FORM 77
8.4 WITNESS ACCOUNT REPORT FORM 80
8.5 PHONE THREAT REPORT FORM 84
8.6 WRITTEN THREAT REPORT FORM 87
8.7 WATER QUALITY/CONSUMER COMPLAINT REPORT FORM 90
8.8 PUBLIC HEALTH INFORMATION REPORT FORM 92
8.9 OVERVIEW OF THE "WATER CONTAMINANT INFORMATION TOOL" 94

LIST OF FIGURES

FIGURE 2-1: CONTAMINATION THREAT MANAGEMENT DECISION TREE 12
FIGURE 2-2: SUMMARY OF THREAT WARNINGS 20
FIGURE 2-3: OVERVIEW OF SITE CHARACTERIZATION AND SAMPLING PROCESS 31
FIGURE 2-4: DECISION PROCESS FOR CONTAINMENT AS AN OPERATIONAL RESPONSE TO A 'POSSIBLE' CONTAMINATION THREAT 33
FIGURE 2-5: SUMMARY OF LABORATORY TYPES BY CONTAMINANT CLASS 41
FIGURE 2-6: DECISION PROCESS FOR THE DEVELOPMENT OF AN ANALYTICAL APPROACH FOR POTENTIALLY CONTAMINATED WATER SAMPLES 42
FIGURE 2-7: DECISION FOR ACTIONS TAKEN TO PROTECT PUBLIC HEALTH IN RESPONSE TO A 'CREDIBLE' CONTAMINATION THREAT 47
FIGURE 2-8: OVERVIEW OF RESPONSE TO A CONFIRMED CONTAMINATION INCIDENT 52

ACRONYMS

AWWARF	American Water Works Association Research Foundation
CDC	Centers for Disease Control and Prevention
ERP	Emergency response plan
ETV	Environmental Technology Verification
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
HazMat	Hazardous materials
ISAC	Information Sharing and Analysis Center
LRN	Laboratory Response Network
PPE	Personal protective equipment
QA	Quality assurance
QC	Quality control
SCADA	Supervisory control and data acquisition
SDWA	Safe Drinking Water Act
TOC	Total organic carbon
URL	Uniform resource locator
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
WCIT	Water contaminant information tool
WUERM	Water utility emergency response manager

GLOSSARY

Definitions in this glossary are specific to the Response Protocol Tool Box but conform to common usage as much as possible.

Agency – a division of government with a specific function, or a non-governmental organization (e.g., private contractor, business, etc.) that offers a particular kind of assistance. In the incident command system, agencies are defined as jurisdictional (having statutory responsibility for incident mitigation) or assisting and/or cooperating (providing resources and/or assistance).

Analytical Approach – a plan describing the specific analyses that are performed on the samples collected in the event of a water contamination threat. The analytical approach is based on the specific information available about a contamination threat.

Analytical Confirmation – the process of determining an analyte in a defensible manner.

Causative Agent – the pathogen, chemical, or other substance that is the cause of disease or death in an individual.

'Confirmed' – in the context of the *threat evaluation* process, a water contamination incident is 'confirmed' if the information collected over the course of the threat evaluation provides definitive evidence that the water has been contaminated.

'Confirmatory' Stage – the third stage of the threat evaluation process from the point at which the threat is deemed 'credible' through the determination that a contamination incident either has or has not occurred.

Consequence – the adverse outcome resulting from a drinking water contamination incident. In the context of the threat management process, the consequence considers both the number of individuals potentially affected as well as the severity of the health effect experienced upon exposure.

Contamination Site – the location where a contaminant is known or suspected to have been introduced into a drinking water system. For example, a distribution system storage tank where a security breach has occurred may be designated as a suspected contamination site. The contamination site will likely be designated as an *investigation site* for the purpose of *site characterization*.

'Credible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'credible' if information collected during the threat evaluation process corroborates information from the *threat warning*.

'Credible' Stage – the second stage of the threat management process from the point at which the threat is deemed 'possible' through the determination as to whether or not the threat is 'credible'.

Drinking Water Primacy Agency – the *agency* that has primary enforcement responsibility for national drinking water regulations, namely the Safe Drinking Water Act as amended. Drinking water primacy for a particular state may reside in one of a variety of agencies, such as health departments, environmental quality departments, etc. The drinking water primacy agency is typically the State Health Agency or the State Environmental Agency. The drinking water primacy agency may also play the role of *technical assistance provider* to drinking water utilities.

Emergency Operations Center – a pre-designated facility established by an agency or jurisdiction to coordinate the overall agency or jurisdictional response and support to an emergency.

Emergency Response Plan – a document that describes the actions that a drinking water utility would take in response to various emergencies, disasters, and other unexpected incidents.

Field Safety Screening – screening performed to detect any environmental hazards (i.e., in the air and on surfaces) that might pose a threat to the *site characterization* team. Monitoring for radioactivity as the team approaches the site is an example of field safety screening.

Health Care Provider – any individual or organization involved in the care of patients. Health care providers include physicians and hospitals.

Immediate Operational Response – an action taken in response to a 'possible' contamination threat in an attempt to minimize the potential for exposure to the potentially contaminated water. Immediate operational response actions will generally have a negligible impact on consumers.

Impact – the consequence or effect on drinking water consumers, or the utility itself, resulting from the implementation of response actions. An impact could also be considered as the cost of implementing a response action.

Incident – a confirmed occurrence that requires response actions to prevent or minimize loss of life or damage to property and/or natural resources. A drinking water contamination incident occurs when the presence of a harmful contaminant has been confirmed.

Incident Command System – a standardized on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure appropriate for the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Incident Commander – the individual responsible for the management of all incident operations.

Investigation Site – the location where site characterization activities are performed. If a suspected *contamination site* has been identified, it will likely be designated as a primary investigation site. Additional or secondary investigation sites may also be identified due to the potential spread of a contaminant.

Latency Period – the period of time that elapses between exposure of an individual to a *causative agent* and the appearance of signs or symptoms of disease.

'Possible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'possible' if the circumstances of the *threat warning* appear to have provided an opportunity for contamination.

'Possible' Stage – the first stage of the threat management process from the point at which the *threat warning* is received through the determination as to whether or not the threat is 'possible'.

Preponderance of Evidence – an overwhelming and convincing amount of information that is sufficient to conclude that an incident has occurred even though definitive proof may not be available.

Public Health – the health and well being of an entire population or community. Public health does not specifically address the health of individuals.

Quality Assurance – an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Control – the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the client; operational techniques and activities that are used to fulfill requirements for quality.

Rapid Field Testing – analysis of water during *site characterization* using rapid field water testing technology in an attempt to tentatively identify contaminants or unusual water quality.

Response Decisions – part of the threat management process in which decisions are made regarding appropriate response actions that consider: 1) the conclusions of the *threat evaluation*, 2) the consequences of the suspected contamination incident, and 3) the impacts of the response actions on drinking water customers and the utility.

Response Guidelines – a manual designed to be used **during** the response to a water contamination threat. Response Guidelines should be easy to use and contain forms, flow charts, and simple instructions to support staff in the field or decision officials in the *Emergency Operations Center* during management of a crisis.

Security Breach – an unauthorized intrusion into a secured facility that may be discovered through direct observation, an alarm trigger, or signs of intrusion (e.g., cut locks, open doors, cut fences). A security breach is a type of *threat warning*.

Site Characterization – the process of collecting information from an *investigation site* in order to support the evaluation of a drinking water contamination threat. Site characterization

activities include the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection.

Technical Assistance Provider – any organization or individual that provides assistance to drinking water utilities in meeting their mission to provide an adequate and safe supply of water to their customers. The *drinking water primacy agency* may serve in this capacity.

Threat – an indication that a harmful *incident*, such as contamination of the drinking water supply, may have occurred. The threat may be direct, such as a verbal or written threat, or circumstantial, such as a security breach or unusual water quality.

Threat Evaluation – part of the threat management process in which all available and relevant information about the threat is evaluated to determine if the threat is 'possible' or 'credible', or if a contamination *incident* has been 'confirmed.' This is an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

Threat Management – the process of evaluating a contamination threat and making decisions about appropriate response actions. The threat management process includes the parallel activities of the *threat evaluation* and making *response decisions*. The threat management process is considered in three stages: 'possible', 'credible', and 'confirmatory.' The severity of the threat and the magnitude of the response decisions escalate as a threat progresses through these stages.

Threat Warning – an unusual occurrence, observation, or discovery that indicates a potential contamination incident and initiates actions to address this concern.

Vulnerability Assessment – a systematic process for evaluating the susceptibility of critical facilities to potential threats and identifying corrective actions that can reduce or mitigate the risk of serious consequences associated with these threats.

Water Contamination Incident – a situation in which a contaminant has been successfully introduced into the system. A water contamination incident may or may not be preceded by a water contamination threat

Water Contamination Threat – a situation in which the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. Compare *water contamination threat* with *water contamination incident.* Note that tampering with a water system is a crime under the Safe Drinking Water Act as amended by the Bioterrorism Act.

Water Utility Emergency Response Manager (WUERM) – the individual(s) within the drinking water utility management structure that has the responsibility and authority for managing certain aspects of the utility's response to an emergency (e.g., a contamination threat) particularly during the initial stages of the response. The responsibilities and authority of the WUERM are defined by utility management and will likely vary based on the circumstances of a specific utility.

1 Introduction

The goal of terrorism is to instill fear in the population, not necessarily to cause damage or casualty. This fear can be caused by the mere *threat* of contamination if the threat is not properly managed. For this reason, both threatened and actual contamination *incidents* are a concern faced by the public at large and, in particular, drinking water treatment professionals. Historic evidence suggests that the probability of intentional contamination of the drinking water supply is relatively low; however, experts agree that it is possible to contaminate a portion of a drinking water system, resulting in adverse public health consequences. Furthermore, as discussed in Module 1, the probability of a contamination threat (the mere indication that contamination of the drinking water supply may have occurred) is relatively high. Given that it is possible to contaminate drinking water at levels of public health concern, and the probable occurrence of contamination threats in the water sector, there is a need to evaluate the credibility of any contamination threat and identify appropriate response actions in a very short period of time.

While it is desirable to have complete information prior to making important decisions, the reality is that decisions typically must be made with incomplete information. This will often be the case when responding to contamination threats to drinking water systems since there will not be time to definitively determine whether or not the water has been contaminated with a harmful substance prior to making decisions to protect public health. However, it is also necessary to avoid false alarms that would result in undue panic and stress on the public. Thus a balance must be achieved between actions taken to protect public health and limiting false alarms and overreaction to a perceived threat. FEMA offers an on-line course in decision making and problem solving in emergency situations that may be of interest to the reader (FEMA, 2002)

This module, the "Contamination Threat Management Guide," provides a framework for making decisions based on available, yet incomplete, information in response to a contamination threat. It represents the hub of the "Response Protocol Toolbox," and is supported by the other modules that present procedures for collecting additional information to assist in evaluating the threat or describe various actions that might be taken in response to a contamination threat. Based on this overarching relationship among the modules, the objectives of this module are to:

- Present a framework for evaluating a water contamination threat and making decisions at key decision points in the process.
- Describe the type of information that may be useful for conducting a *threat evaluation*.
- Describe the actions that might be implemented in response to a contamination threat, giving consideration to the potential consequences of an incident and the *impacts* resulting from various response actions.

Based on these objectives, Module 2 is organized into eight sections that deal with the following topics:

Section 1: <u>Introduction</u>: Describes the objectives and overall organization of this module.

Section 2: Overview of the Contamination Threat Management Process: Provides an overview of the process for evaluating a contamination threat and making decisions about appropriate response actions based on the conclusions drawn from the threat evaluation and an analysis of potential consequences.

Section 3: 'Possible' Stage of the Threat Management Process: Describes the general approach for determining whether or not a water contamination threat is '*possible*,' as well as the information sources and response actions that might be considered at this initial stage of the threat evaluation.

Section 4: 'Credible' Stage of the Threat Management Process: Describes the general approach for determining whether or not a water contamination threat is '*credible*,' as well as the information sources and response actions that might be considered at this advanced stage of the threat evaluation.

Section 5: 'Confirmatory' Stage of the Threat Management Process: Describes the general approach for determining whether or not a water contamination incident has been '*confirmed*.' Discusses the information that might be used to confirm an incident as well as the response actions that might be implemented once an incident has been confirmed.

Section 6: Contamination Threat Management Matrices: Presents eight matrices that describe the three stages of a threat evaluation ('*possible*,' '*credible*,' and '*confirmed*') for each type of *threat warning* presented in this module.

Section 7: References and Resources: Lists the references used in the development of this module as well as additional information resources.

Section 8: Appendices: provides a number of forms that support this module and that may be used in the development of a utility's site-specific *Emergency Response Plan* (ERP) or *Response Guidelines* (RGs).

The target audience for this module includes any individuals that might be involved in evaluating the possibility or credibility of a water contamination threat, providing information to support the evaluation, or deciding on appropriate response actions based on the results of the threat evaluation. This will likely include water utility management and staff, *drinking water primacy agency* staff, public health officials, *technical assistance providers*, and law enforcement officers. This module is intended to be a planning tool, and it is recommended that individuals responsible for managing a contamination threat (including an evaluation of the credibility of the threat and response actions to the threat) review this module in its entirety and integrate the concepts presented herein into their own response guidelines.

2 Overview of the Contamination Threat Management Process

This section provides an overview of the entire *threat management* process and serves as a roadmap to the remaining sections of this module. This overview is intended to familiarize the reader with the entire process such that details of the methodology provided in the subsequent sections can be understood in the context of the overall framework. Figure 2-1 is a flow chart depicting the threat management process, which is comprised of two parallel activities: the *threat evaluation* and *response decisions*. While these two activities are interdependent and are performed concurrently during the threat management process, each is presented separately to facilitate the discussion.

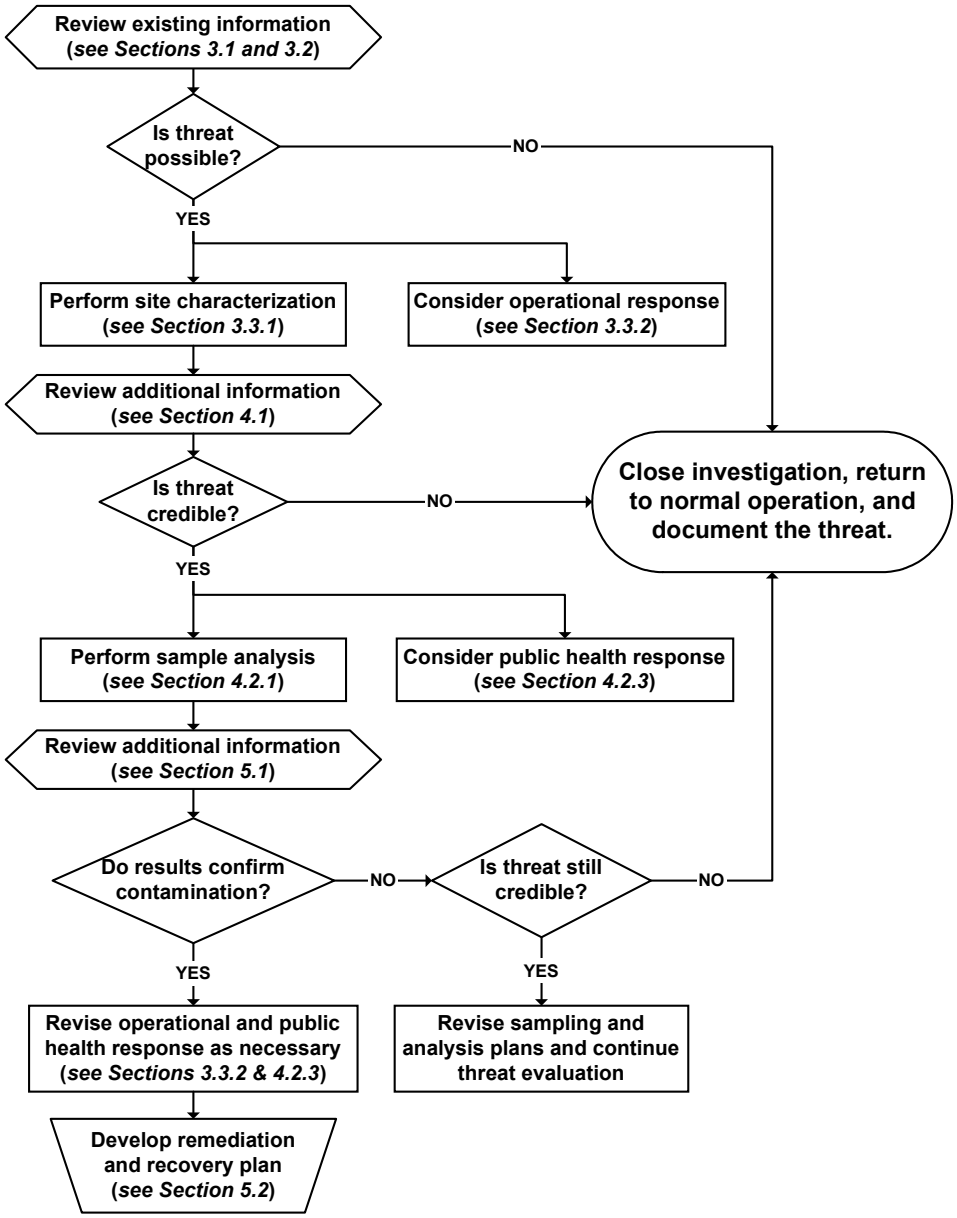


Figure 2-1. Contamination Threat Management Decision Tree

The general decision tree for managing a contamination threat presented in Figure 2-1 is a model that should be applied according to the circumstances of a specific situation. There are numerous discoveries at water facilities that might be interpreted as potential contamination threats, and the decision tree presented in Figure 2-1 is intended to reduce the thousands of potential discoveries to hundreds of possible contamination threats to tens of credible contamination threats. This will in turn allow a utility to respond appropriately to contamination threats that do occur and provide reasonable consideration to the threat without overreacting and triggering harmful false alarms.

2.1 Roles and Responsibilities

Module 1 presented the *Incident Command System* as a model of the organizational structure for managing a contamination threat or incident. Under this structure, the individual with overall responsibility is the *incident commander*. The organization that assumes responsibility for incident command will depend on the nature and severity of the threat or incident. By default, if no other organization with the proper authority assumes responsibility for incident command, it becomes the water utility's responsibility. The *water utility emergency response manager* (WUERM) would assume the role of incident commander in this case.

During the course of managing a contamination threat, the individual designated as incident commander may change as different organizations assume responsibility for managing the situation. For example, during the initial stages of a situation, the WUERM will likely be in the role of incident commander. As more information about the threat becomes available and the situation evolves, different organizations may step in and take command. For example, if terrorist activity is suspected, the FBI will likely assume incident command. On the other hand, if the situation were a potential *public health* crisis (without links to terrorism), the state or local public health agency would likely assume incident command. In cases where another organization has assumed responsibility for incident command, the utility will play a supporting role during the threat management process and maintain responsibility for the system.

The following is a brief discussion of roles and responsibilities during the threat management process. This listing is not intended to be comprehensive for all situations, but to highlight the key players that might be involved in the threat evaluation or in making response decisions.

Drinking Water Utility – The utility will be responsible for incident command, and the WUERM would be designated as the incident commander, unless another organization takes over the situation. As incident commander, the WUERM would be responsible for conducting the threat evaluation and making response decisions. Regardless of the organization responsible for incident command, the utility has an ongoing responsibility as a technical advisor to the incident commander for issues related to the operation of the water system and water quality.

Drinking Water Primacy Agency – This agency may assume responsibility for incident command in cases in which the water utility lacks the resources to manage the threat. The primacy agency may also coordinate some aspects of response and reporting throughout its jurisdiction. Furthermore, the primacy agency may serve as a technical resource to water

utilities and serve as a link to federal resources such as the United State Environmental Protection Agency (U.S. EPA) and the Federal Emergency Management Agency (FEMA).

Public Health Agency (State or Local) – This agency may assume responsibility for incident command in situations in which there is a potential threat to public health. The public health agency will have the lead in coordinating the public health response to a contamination threat or incident, possibly including public notification. They would also have the lead in the public health investigation, including identification of the source of unusual disease or death in the population. The public health agency would also serve as the link to federal resources such as the Centers for Disease Control and Prevention (CDC) and the Laboratory Response Network (LRN). Note: in some states, the state public health agency is also the drinking water primacy agency.

Local Law Enforcement Agency– This agency may assume responsibility for incident command in situations in which criminal activity, excluding federal crimes, is suspected. Law enforcement will have the lead in the criminal investigation and will determine whether or not a crime has been committed. The criminal investigation (i.e., has a crime been committed?) is related to the threat evaluation process, which addresses the more specific question regarding whether or not the water has been contaminated.

Federal Bureau of Investigation (FBI) – This agency ***will*** assume responsibility for incident command when a federal crime, including terrorism, is suspected. Furthermore, FBI will make the determination regarding the credibility of a terrorist threat based on the information available and their experience in criminal investigations. If FBI determines the terrorist threat to be credible, they will assume command of the situation, and the utility will play a technical advisory role.

The roles of federal organizations during the response to an incident are defined in the Federal Response Plan, which is described in Module 1, Appendix 6.2.

2.2 Evaluation of Water Contamination Threats

The process begins with a *threat warning*, which is an unusual event, observation, or discovery that indicates a potential contamination incident and which initiates actions to address this concern. For example, a *security breach* at a distribution system storage tank might be considered a threat warning. A threat warning will typically result in a *threat evaluation*, a process in which all available and relevant information is evaluated to determine the credibility of a contamination threat. The following simple model described the threat evaluation in terms of input, evaluation, and output:

- Input = all available information relevant to the contamination threat.
- Evaluation = systematic evaluation of the **collective** information to determine whether or not the water supply could have been contaminated. It is important to consider all available information as a whole such that any one individual piece of information does not drive the entire decision process.
- Output = conclusions of the threat evaluation (i.e., has something actually happened?).

The threat evaluation is a progressive process that is considered in three stages (or decision points) depicted in Figure 2-1: '*possible*,' '*credible*,' and '*confirmed*.' These stages are briefly described below and discussed more fully in Sections 3, 4, and 5. It is also an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

The primary focus of the threat evaluation is public health (i.e., has the water been contaminated at levels of public health concern?). However, the threat evaluation should also consider other potential consequences of a contamination incident such as infrastructure damage, adverse impacts on the aesthetic qualities of the drinking water, and reduced consumer confidence.

Management of a contamination threat begins with an evaluation of information about the threat warning. The outcome of this initial evaluation leads to the first decision point in Figure 2-1 – "is the threat possible?" This initial evaluation represents a relatively low threshold that is intended to discriminate between those threats that warrant further investigation and those that can be dismissed as impossible. If the threat is deemed possible, *immediate operational responses* may be implemented to contain the suspect water while the investigation is continued through activities such as site characterization to support the next stage of the threat evaluation. If the threat is not considered 'possible,' the investigation is closed, the threat documented, and the system returned to normal operation.

The results of site characterization and investigation of other sources will yield additional information that will inform the second decision point in Figure 2-1 – "is the threat credible?" This decision represents a higher threshold than that at the *'possible' stage*. In order for a threat to be considered 'credible,' there must be sufficient information and corroborating evidence to indicate that the water may have been compromised. If the threat is determined to be 'credible,' response actions may be necessary to limit the potential for human exposure to the suspect water and law enforcement should be notified due to the potential for criminal activity. The investigation will continue concurrently with these response actions in an effort to confirm the contamination incident. Actions taken to confirm an incident may include the analysis of samples collected during site characterization and/or additional sampling and *rapid field testing*. If the threat is not considered 'credible,' the investigation is closed, the incident documented, and the system returned to normal operation.

The next and final decision point in Figure 2-1 is confirmation of a contamination incident, which will typically be achieved in one of two ways. The preferred approach for confirmation of a contamination incident is through an evaluation of analytical results from samples collected during site characterization. However, this may not always be possible due to the limitations of both sampling and analysis (e.g., sampling may fail to capture an aliquot of the contaminated water). Thus, a contamination incident may also be confirmed through a *preponderance of evidence* indicating that the water has been contaminated. As an example, a contamination incident might be confirmed if there is a security breach with obvious signs of contamination and there are reports of unusual health symptoms in residents near the site of the security breach.

Once a contamination incident is confirmed, it may be necessary to revise protective measures previously implemented in order to ensure that the public will not be exposed to the

contaminated water. Furthermore, it will be necessary to prepare for remediation and recovery activities following confirmation. If the analytical results do not confirm the contamination incident, the credibility of the threat should be reassessed. Upon reassessment, if the threat is **still** deemed credible, it may be necessary to revise the sampling and/or analysis approach since it is possible that the first round of sampling and analysis missed the contaminant. On the other hand, if the threat is no longer considered 'credible' due to negative analytical results and a lack of other evidence, the investigation can be closed, the incident documented, and the system returned to normal operation. However, under such circumstances, it will likely be necessary to collect and analyze a number of samples in the suspect area to provide additional assurance that the water has not been contaminated and is safe to use.

2.3 Consequence Analysis

Effective management of a contamination threat lies in the ability to make appropriate decisions and take appropriate actions in response to the threat. As previously discussed, the credibility of a contamination threat is one consideration in making these response decisions. An equally important consideration is the potential *consequence* to public health. Thus, an analysis of potential consequences associated with a particular contamination threat is a complementary effort to the threat evaluation. Like the threat evaluation, consequence analysis should be viewed as an iterative process since the potential consequences of a particular threat may be better understood as additional information is collected from the ongoing investigation. In conducting a consequence analysis, one should consider the number of individuals potentially affected, the severity of the health effects, and the impact of an interruption in the drinking water supply on consumers.

2.3.1 Number of Individuals Affected

The number of individuals potentially affected by a contamination incident is a function of the spread of the contaminant and the population within the contaminated area. This may be difficult to determine with a great deal of accuracy within the short time period necessary to make response decisions; however, it may be possible to quickly develop a rough estimate using existing information and/or tools. A simple approach is to utilize operational knowledge of the system to approximate the spread of the potentially contaminated water from the point of suspected contaminant introduction. One might also develop a list of typical travel times from key nodes or facilities within the system to large population centers or critical customers.

A more rigorous evaluation approach involves the application of a hydraulic model designed to estimate the spread of a contaminant from a point of introduction through the distribution system. Examples of models that could be applied in this manner include EPA Net, PipelineNet, MWHSoft, Stoner, and Haestad. The capabilities of PipelineNet are described in more detail in Module 5, Appendix 8.7. These models are sophisticated and require a certain level of skill and a significant amount of time to run; thus, it may not be practical to use such models during the early stages of a response to a contamination threat. Furthermore, the successful application of these models depends on knowledge of the location and time of contaminant introduction, information that may not be available in many cases. It may be more useful to run several

scenarios using a hydraulic model as a planning exercise in order to understand how a contaminant might move through a system.

Once the area impacted by the spread of the contaminant has been estimated, the number of individuals potentially affected can be approximated using the population within that area. The population might be estimated from knowledge of the population centers, neighborhoods, and institutions within the bounds of the affected area. Consideration must also be given to the dilution that would occur as a contaminant moves through the system and the relatively small percentage of treated water that is used for consumption. Both of these factors will reduce the number of individuals potentially affected, but not necessarily to levels acceptable to the public.

2.3.2 Health Effects

The severity of the health effects is directly related to the properties and concentration of the contaminant. In cases where the identity of a contaminant is known or assumed, information about its toxicity/infectivity, fate and transport, and resistance to chlorine or chloramines will help in the assessment of potential public health impacts. Health effects might be minor (e.g., minor skin irritation), moderate (e.g., short-term gastrointestinal disease), or severe (e.g., debilitating disease or death). Situations in which there may be sufficient information to make a reasonable assessment of potential health effects include those in which a contaminant is named in a threat, detected through monitoring or analysis, or inferred from clinical data. Information regarding contaminant properties related to public health effects may be obtained from local health authorities, U.S. EPA, and CDC, among others. Unfortunately, in most cases there will not be sufficient information about the suspected contaminant to make an assessment regarding potential health effects. In these instances, it may be appropriate to make the conservative assumption that severe health effects are possible.

2.3.3 Impacts of Response Actions on Consumers

While public health protection is the **primary** objective during management of a contamination threat, it is also important to consider the overall mission of the water utility – to provide a safe supply of drinking water for consumption, sanitation, fire protection, and other consumer needs. Response actions can be taken to minimize possible impacts on public health that could result from an actual contamination incident, but many of these actions will impact the ability of the water system to meet various aspects of its overall mission. For example, if a decision is made to issue a “do not drink” notice, the day-to-day life of citizens will be severely impacted due to the loss of a convenient supply of potable water for consumption and food preparation. Furthermore, if the water is deemed unsafe for fire fighting, an alternate source must be quickly mobilized to maintain fire protection.

2.4 Planning for Response Decisions

Three factors should be considered when planning for decisions regarding actions taken in response to a contamination threat: 1) the credibility of the threat; 2) the potential consequences of the contamination incident; and 3) the impact of the response action on consumers. A “Response Planning Matrix” is a tool that may help decision officials to consider these three

factors when planning for response decisions and might serve as a quick reference guide during an actual crisis. The matrix is a simple tabular summary that lists the three levels of a threat evaluation, the potential consequences of a threat (both the number of people affected and health effects), and potential response actions along with their impacts on consumers. A blank "Response Planning Matrix" is included in Appendix 8.1.

By planning for threats with different levels of credibility and potential consequences, the utility will be better able to make appropriate response decisions quickly. The Response Planning Matrix will also make it clear when response decisions need to be elevated to a higher level within the utility chain of command or coordinated with an external organization, such as the public health agency. Furthermore, an understanding of the potential impacts of various response actions will provide an opportunity to develop strategies for managing and minimizing adverse impacts. For example, the impact associated with issuing a "do not drink" notice might be mitigated through a public awareness program. This outreach approach could educate the public to the possibility of short duration water outages and encourage them to store a supply of emergency drinking water. Such practice is common in areas prone to natural disasters such as earthquakes and hurricanes.

The blank matrix provided in the appendix can be used as an aid during emergency response planning. By working through scenarios with different combinations of credibility, consequences, and impacts, it is possible to gage the relative importance of various factors. For example, it may be determined that the response decisions are influenced more by 'the number of people affected' than the 'health effects.' Since there are a limited number of response actions available to any utility, it is likely that the number of combinations in the matrix will reduce to just a few, and the factors that have the greatest impact on response decisions will become apparent.

Once the planning process is complete, the "Response Planning Matrix" can be completed as necessary to serve as a quick reference guide that could be incorporated in a set of "*Response Guidelines*." The tool may also need to be modified from its current form in Appendix 8.1 to be consistent with a utility's planning process (for example, the "number of people affected" might be changed to "area affected"). During a crisis, such a tool can efficiently guide the WUERM toward appropriate planned response actions under various conditions or scenarios.

3 'Possible' Stage of the Threat Management Process

A water contamination threat is characterized as 'possible' if the circumstances of the threat warning indicate that there was an opportunity for contamination. This is the lowest threshold in the threat evaluation process and is the point at which a decision is made regarding whether or not to proceed with the investigation. If the threat is determined to be impossible, there is no need to continue the threat evaluation or consider any response actions. However, it is likely that many contamination threats will meet this relatively low threshold and thus warrant further investigation.

The target time period for determining whether or not a contamination threat is 'possible' is within **one hour** from the time the threat warning is received by the utility. Given the potentially severe consequences of failing to respond to an actual contamination incident in a timely and appropriate manner, it is important to determine whether or not a threat is 'possible' in this relatively short time frame. The one-hour target, however, should be treated as a flexible goal since the circumstances of a particular threat may dictate a shorter or longer time

As with all stages of the threat management process, the incident commander is responsible for determining whether or not contamination threat is 'possible.' In most cases, this determination will be made by the WUERM, although others may become involved in this initial evaluation as appropriate. For example, if the threat warning is reported by a law enforcement agency, they would likely play a role in determining whether or not a threat is 'possible.' Also, the drinking water primacy agency may wish to be informed about all threat warnings and may participate in this initial stage of the threat evaluation. However, given the short target time frame for this initial evaluation, it is generally recommended that the WUERM have the authority to make this determination and the decision to continue the investigation.

Relevant and timely information is key to determining whether or not a threat is 'possible' in the target time period. In most cases, the information considered at this stage will be derived directly from the threat warning (e.g., type of warning, location, time of discovery, suspected time of incident, and other details). Under some circumstances, additional information beyond the threat warning may be considered. However, there may not be sufficient time to do so in most cases, and the determination regarding whether or not the threat is 'possible' will be based primarily on the details of the threat warning.

3.1 Information from the Threat Warning

A *threat warning* is an unusual event, observation, or discovery that indicates the potential for contamination and initiates actions to address the concern. Threat warnings may come from several sources from both within and outside of the water utilities as shown in Figure 2-2.

Information extracted from details of the threat warning is critical to determining whether or not a contamination threat is possible, and different types of warnings will have different levels of initial credibility. For example, a public health notification of unusual disease or death in the population would have a higher degree of initial credibility than a report of unusual water quality based on general parameters (e.g., pH, chlorine residual, etc.). Some warnings may be judged so

reliable that the threat is deemed 'credible' solely on the basis of information about the threat warning, while others may be almost instantly dismissed as impossible. Each type of threat warning depicted in Figure 2-2 is discussed in greater detail in following subsections, particularly with respect to the initial reliability of the information from such incidents.

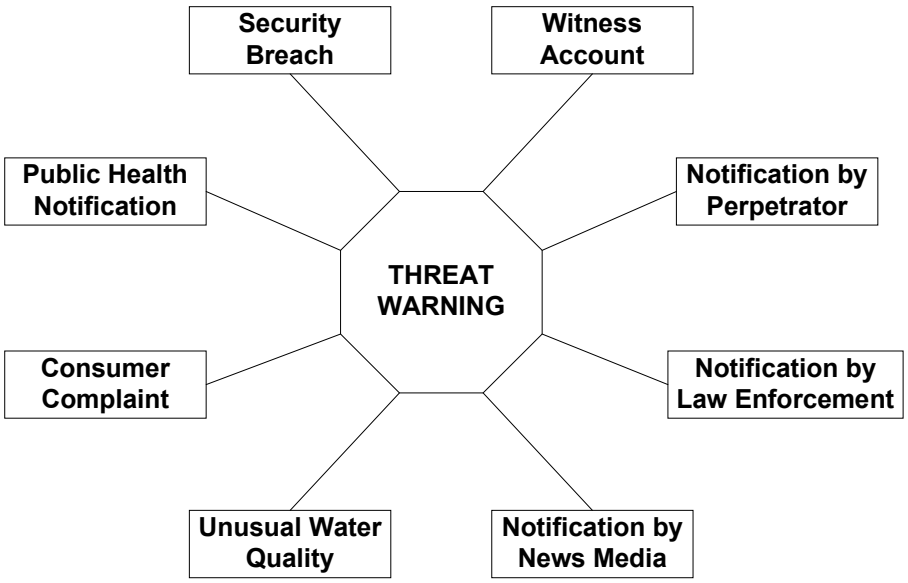


Figure 2-2. Summary of Threat Warnings

Regardless of the nature and source of the threat warning, it is critical that protocols be in place to report the warning to the WUERM as quickly as possible. Utilities and communities should develop communications channels and procedures to ensure that threat warnings can be accurately and quickly reported on 24/7 basis. A "Threat Evaluation Worksheet" is provided in Appendix 8.2 to help organize the information used throughout the threat evaluation, beginning with a summary of information about the threat warning itself.

3.1.1 Security Breach

A security breach is an unauthorized intrusion into a secured facility that may be discovered through direct observation, an alarm trigger, or signs of intrusion (e.g., cut locks, open doors, cut fences). Security breaches are probably the most common threat warnings, but in **most** cases are related to day-to-day operation and maintenance within the water system. Other security breaches may be due to criminal activity such as trespassing, vandalism, and theft rather than attempts to contaminate the water. However, it is prudent to assess any security breach with respect to the possibility of contamination.

When evaluating whether or not a security breach is a possible contamination threat, it is important to consider the circumstances of the incident:

- The mode of discovery of the security breach, e.g., discovery by utility crews, law enforcement, a citizen, security alarm, etc. "Is the source reliable?"

- The time window in which the security breach occurred. "Can a time window be established for the incident based on the times of previous visits to the site and/or the time of discovery?"
- The area in which the security breach occurred. "Is there a history of break-ins, vandalism, or trespassing in this area?"
- Any other information or circumstances about the incident. "Are there signs of theft, vandalism, or mischief?" "Are there indications that multiple individuals were involved?" "Was anything left at the site?"

A "Security Incident Report Form" is included in Appendix 8.3 to assist in documenting the available information about the breach and support the threat evaluation.

If the site of the security breach is equipped with security cameras, the footage should be reviewed as part of the threat evaluation. A video record of the security breach can provide valuable information to help distinguish among normal operational activity, simple trespassing, and 'possible' or 'credible' contamination threats. Furthermore, it can help to establish the actual time of the security breach, which is critical for estimating the area of a distribution system that would be affected if a contaminant were actually introduced (i.e., such information would aid in consequence analysis).

The information about a security breach available at the time of discovery may be sufficient to determine whether or not a threat is 'possible.' However, in most cases additional information will be necessary to determine whether or not the threat is 'credible.' Information collected during *site characterization* activities will be critical to the threat evaluation at this later stage, as discussed in Section 4.1.1.

3.1.2 Witness Account

A threat warning may come from an individual who directly witnesses suspicious activity, such as trespassing, breaking and entering, or some other form of tampering. The witness could be either a utility employee or a bystander. As a result, the witness report may come directly to the utility, or may be directed to a 911 operator or law enforcement agency. If the witness reports the incident to a law enforcement agency, a written or verbal report from the police may provide some insight regarding the possibility of contamination. Furthermore, if the suspect(s) was apprehended, the police report may include additional insight regarding the motives and circumstances of the episode. It is important that the utility establish a relationship with local law enforcement agents, as individuals observing suspicious behavior near drinking water facilities will likely call 911 or law enforcement rather than the water utility.

It is important to collect as much information as possible from the witness to support the initial threat evaluation. A "Witness Account Report Form" is included Appendix 8.4 to help document the witness account. If the witness has not already been interviewed, or if the interview did not cover all aspects of the event that are relevant to the utility's threat evaluation, the WUERM should contact law enforcement and arrange to interview with the witness. In some cases, law enforcement officials may prefer to conduct the interview themselves, but the WUERM may be able to suggest certain questions that are relevant to the threat from the

perspective of the water utility. Information from the witness that would be important to the utility's evaluation includes the number of individuals, their actions at the site, equipment or containers handled by the perpetrators, and anything taken from the site. It is also important to consider the reliability of the source when evaluating information from any witness account,. For example, a threat warning delivered by an individual with a history of filing false reports with police should be considered suspect until corroborated by additional information. On the other hand, direct observation by utility staff would be considered a reliable threat warning.

3.1.3 Direct Notification by Perpetrator

A threat may be made directly to the water utility, either verbally or in writing. Verbal threats made over the phone are historically the most common type of direct threats from perpetrators; however, written threats have also been delivered to utilities. Report forms for both phone and written threats are provided in Appendices 8.5 and 8.6, respectively. A direct notification should be evaluated with respect to both the nature of the threat and specificity of information provided in the threat. In the case of a phone threat, the caller should be questioned about the specifics of the threat: time and location of the incident, name and amount of the contaminant, reason for the attack, the name and location of the caller, etc. The characteristics of the caller should be noted as well (e.g., male/female, accent, tone of voice, background noise, etc.). Given the number of different individuals that might receive a phone threat at a utility, there is a need for training and frequent updates regarding procedures for handling phone threats. In a similar manner, mailroom staff should be provided with training regarding the recognition and handling of suspicious packages and letters. Guidance for dealing with suspicious packages has issued been issued by the US Postal Service (http://www.usps.com/news/2001/press/pr01_1022gsa.htm).

Since tampering with a drinking water system is a crime under the Safe Drinking Water Act, and may involve several other felony acts, any threats received by a utility should be reported to the appropriate authorities, including law enforcement and drinking water primacy agency.

3.1.4 Notification by News Media

A threat to contaminate the water supply might be made through the news media, or the media may discover and report a threat before the utility is alerted. Thus, it is important that utilities establish relationships with the media to emphasize the importance of notifying the utility or the drinking water primacy agency immediately if a threat against the water supply is received. An established contact should be available to receive such calls at any time. If the threat is general (i.e., not targeted at a specific town or city), the utility should evaluate the reported information and may wish to discuss the threat with their primacy agency. The utility may also consider notifying local law enforcement about the general threat.

In the case of a threat against the water supply for a specific city, a conscientious reporter would immediately report the threat to the police, and either the media or the police should immediately contact the water utility. Assuming this level of professionalism in the media, the notification would go directly to the utility or law enforcement. This early notification would provide an opportunity for the utility to work with law enforcement agencies toward assessing the possibility of the threat before any broader notification is made.

Note that a separate report form was not generated for a notification by news media, since this represents a notification pathway rather than a distinct type of threat warning. The "Threat Evaluation Worksheet," and possibly other forms included in the appendices, may be used to document a notification from news media.

3.1.5 Notification by Law Enforcement Agencies

A utility may receive notification about a contamination threat directly from a law enforcement agency. This notification could be a result of suspicious activity reported to the police or a threat to the water supply made through the news media. Other information could also lead law enforcement agents to conclude that there may be a threat to the water supply. In any case, the utility should review the available information with law enforcement to assess whether the threat is possible and decide on appropriate response actions. While law enforcement agents will have the lead in the criminal investigation, the utility has primary responsibility for the safety of the water supply and operation of the water system. Thus, the utility's role will likely be to help law enforcement appreciate the feasibility and public health implications of a particular threat.

Note that a separate report form was not generated for a notification by law enforcement agencies, since this represents a notification pathway rather than a distinct type of threat warning. The "Threat Evaluation Worksheet," and possibly other forms included in the appendices, may be used to document a notification from law enforcement.

3.1.6 Unusual Water Quality

Unusual water quality results may serve as a warning of potential contamination if the data is available in real-time or near real-time. This type of threat warning could come from on-line monitoring, grab sampling, or an early warning system. Appendix 8.7 provides a "Water Quality and Consumer Complaints Report Form," which may be useful when evaluating a threat warning due to unusual water quality.

Unusual water quality data should be evaluated against an established baseline that captures normal variability in the system, both temporally and spatially. Deviations from an established water quality baseline may serve as a threat warning and should be investigated to determine whether or not the results are indicative of potential contamination. In the absence of a baseline, it will be difficult to discriminate between normal variability and legitimate threat warnings – a situation that could lead to unacceptable false alarms. A baseline can be established for any water quality parameter that is routinely monitored, and the following list is intended to be illustrative rather than comprehensive:

- pH of the distributed water is a function of the pH of the finished water at the entry point to the distribution system. In well buffered waters, it will typically remain fairly constant throughout a distribution system in which the water is in equilibrium with the pipe material; however, it may vary if there are corrosion problems.

- Conductivity of the distributed water is a function of the conductivity of the finished water at the entry point to the distribution system. It will typically remain fairly constant throughout a distribution system in which the water is in equilibrium with the pipe material; however, it may vary if there are corrosion problems.

- Chlorine/chloramine residual levels vary as a function of temperature, pH, degree of nitrification, pipe wall demand (i.e., from biofilm or corrosion), and distribution system residence time (i.e., water age). The initial residual is established at the plant and is a function of the disinfectant dose and oxidant demand of the water. Oxidant demand will vary as a function of water quality and typically experiences seasonal fluctuations. The use of disinfectant booster stations in the distribution system must also be considered when evaluating baseline residual data.

- Total organic carbon (TOC) levels in the distributions system will remain relatively constant with respect to the finished water TOC. However, use of strong oxidants, such as ozone, can increase the biodegradable fraction of TOC, potentially resulting in greater variability in TOC levels in the distributions system.

- UV absorbance is typically used as a surrogate for TOC, but is more indicative of the aromatic fraction of TOC. UV absorbance will experience variations similar to TOC and is also impacted by oxidants and disinfectants used in water treatment.

Another factor to consider when establishing a baseline for distribution system water quality is the potential for blending of water quality from different treatment plants. If multiple treatment plants feed the distribution system, the water quality will be a function of the blending ratio of the water from the different plants, in addition to the other factors described above. The task of establishing a baseline for such systems is further complicated by the fact that the blending ratios will vary both spatially and temporally.

Since 9/11, there have been a number of unconventional technologies and parameters suggested as early warning systems that might detect contamination incidents. It is even more important to establish a reliable baseline for an early warning system that relies on such unconventional parameters, since there is not an experience base to support the identification of unusual results without a baseline for comparison. The applicability of on-line monitoring to the detection of intentional contamination incidents is still under study and many questions remain unanswered regarding the applicability of these tools to water security (i.e., general effectiveness, sensor density requirements, false alarm rate, etc.). The topic of on-line monitoring and early warning systems is also discussed in Module 1, Appendix 6.3.

Finally, it is also critical to evaluate a threat warning due to unusual water quality data in light of the performance characteristics of the monitoring and detection equipment. Factors to consider include the rate of false positives, false negatives, known interferences, and instrument reliability. The EPA Environmental Technology Verification (ETV) program has established an on-going program to evaluate the performance of hand held and on-line monitoring and detection technologies. Utilities considering the application of any monitoring technology should evaluate ETV verification reports, if available (www.epa.gov/etv).

3.1.7 Consumer Complaints

An unexplained or unusually high incidence of consumer complaints about the aesthetic qualities of drinking water, or minor health problems resulting from exposure to water (e.g., skin irritation), should be investigated as a potential threat warning. A number of chemicals can impart an odor or taste to water, some may discolor the water, and others might result in minor health problems in exposed individuals. It is also important to realize that a number of chemicals and all pathogens will have no impact on the aesthetic qualities of drinking water; thus, an absence of consumer complaints does not imply that the water is free of contaminants. When evaluating consumer complaints as a potential indicator of contamination, it is important to ask a series of questions:

- Are the complaints significantly different, with respect to number or type, from those associated with typical taste and odor episodes (such as those resulting from lake turnover or algal blooms)?
- What is the specific nature of the compliant? What is the characteristic odor, taste or color? What is the minor health problem experienced by customers?
- Is the reported taste, odor, or color different from those typically reported?
- Is the reported taste, odor, or color characteristic of a particular contaminant?
- Is there an unusual geographic clustering of complaints (e.g., are complaints isolated to a small area of the distribution system)?
- Are the complaints from customers that are not habitual complainers?

The answers to these questions will help to determine whether the complaints are indicative of a possible contamination incident, or typical of normal water quality conditions and routine episodes. Appendix 8.7 provides a "Water Quality and Consumer Complaints Report Form" that may be useful when evaluating a threat warning resulting from unusual consumer complaints.

In order for consumer complaints to be an effective trigger, a utility must have a 24/7 system in place to respond to consumer complaints in a timely fashion. Furthermore, complaint staff should be trained to recognize unusual trends in consumer complaints and have the tools necessary to characterize complaints by type and location. Unusual trends should be reported to the WUERM immediately. A useful resource that describes an approach for investigating consumer complaints as a potential indicator of contamination has been prepared by U.S. Army Center for Health Promotion and Preventative Medicine (2003).

3.1.8 Notification by Public Health Agencies

Notification from a public health agency or *health care providers* (e.g., doctors or hospitals) regarding increased incidence of disease or death is another possible threat warning. This threat warning is obviously contingent on health care professionals associating patterns in exposure and symptoms with potential water supply contamination. A distinction should be made between a notification that comes from public health officials and one that comes directly from health care providers; the former deals with the health of a population, while the latter is concerned with the health of individual patients. Since safe drinking water is a cornerstone of public health, the utility should generally work directly with public health officials rather than individual health care providers. If a threat warning comes in from a health care provider, it should be immediately reported to the local or state public health agency.

A threat triggered by a public health notification is unique in that at least a segment of the population has presumably been exposed to a harmful substance. Given this circumstance, it is likely that public health officials will assume responsibility for incident command and may choose to handle the situation as an epidemiological investigation in an effort to track down the source. During a public health investigation, the utility should work with local or state health officials in a support role.

The role of the drinking water utility will likely be to assist in the evaluation of water as a possible source of the increased disease or death observed in the community. The "Public Health Information Report Form" included in Appendix 8.8 is intended to organize information from public health agencies in a manner to support this evaluation. If the *causative agent* is known (i.e., through clinical data), it may indicate whether or not water is a possible or likely source. For example, if the contaminant is unstable in water, the investigation might focus on other potential sources, such as food.

It is also important to consider the time that would be expected to elapse between exposure and onset of symptoms. If the causative agent is a chemical (including biotoxins and high level radiation), then the time between exposure and onset of symptoms may be on the order of minutes to hours; thus, there is the potential that the contaminant is still present in the water system. On the other hand, the incubation period for most pathogens is on the order of days to weeks, and thus the causative agent may be absent from the system or present only in trace quantities due to water use, dilution, and die-off during the time period between the incident and onset of symptoms. Similarly, the signs of low-level radiation poisoning may not appear immediately following exposure. This time lag will have a significant impact on the response strategy, including both sampling and actions taken to protect public health.

3.2 Additional Information Considered at the 'Possible' Stage

While the threat warning will likely provide the most immediate and relevant information, several other potential resources might be considered at the 'possible' stage. In general, it is assumed that there will only be time to consult resources within the utility at this stage of the threat evaluation given the short time available to determine whether or not the threat is 'possible.' The information resources listed in this section should not be considered comprehensive or mandatory for determining whether or not a threat is 'possible,' since the circumstances of a specific threat are unique and will dictate appropriate information resources. The specific information resources described in this section include:

- Internal utility information from those who know the physical configuration, operation, and typical water quality of the water system.
- Information from the utility's site-specific *vulnerability assessment* that is relevant to the contamination threat.
- Real-time water quality data that might be used as a potential indicator of water contamination, when evaluated in the context of an established baseline.

Even though this information is listed under the 'possible' stage of a threat evaluation, it is important to remember that the analysis of this information will likely continue throughout the

threat evaluation process. Specifically, the same information resources may be used during the 'possible,' 'credible,' and 'confirmed' stages of the threat evaluation, as long as they are relevant. As the investigation continues, additional information will become available and previously collected information may be either confirmed or invalidated. In summary, the threat evaluation process is **continuous** and **iterative** in nature.

3.2.1 Utility Information and Staff Knowledge

Utility staff possess an extensive knowledge about the physical configuration, operation, and water quality of their system. This knowledge should be utilized throughout the entire threat evaluation process, beginning with the assessment of whether or not the threat is 'possible.' Direct experience in dealing with previous security breaches, such as trespassing or vandalism, can provide insight regarding the possibility of contamination during the evaluation of a current threat warning. Knowledge of typical water quality conditions provides a basis for the evaluation of unusual water quality data that might be considered a threat warning. Previous experience with taste and odor episodes may allow staff to recognize unusual patterns in consumer complaints. Furthermore, during advanced stages of an incident, the understanding of distribution system hydraulics by operations staff and engineers will be critical to the rapid assessment of the propagation of a suspected contaminant through a system. In summary, the knowledge and experience of utility staff should be included as a key information resource. Also, the staff can be sensitized to various potential threat warnings so that they can recognize them early and report them to the WUERM in an efficient and timely manner. To facilitate utilization of staff in an emergency, the WUERM should have 24/7 contact information for all critical staff with specialized knowledge of the system.

3.2.2 Vulnerability Assessment

A utility's vulnerability assessment (VA) is another potential source of information to consider during a threat evaluation; however, this will depend on the manner in which the general threat of intentional contamination was addressed during the VA. Information that could be derived from a VA to support the threat evaluation of a specific contamination threat might include:

- Locations potentially considered as high value targets of intentional contamination (e.g., large population centers, government buildings, etc.).
- Locations considered particularly vulnerable to the intentional introduction of contaminants.
- Other site-specific considerations, such as the availability of a particular contaminant in an area.

This information might be of particular value during the evaluation of general contamination threats in which neither a location nor a contaminant is specified or suspected. Ideally, such information would be derived from a VA and summarized as part of utility planning for response to contamination threats (i.e., rather than referring to the complete VA in the midst of a crisis).

3.2.3 Real-time Water Quality Data and Consumer Complaints

Unusual water quality data is a potential threat warning but may also serve as a valuable source of information during the evaluation of a threat triggered by another type of threat warning. For example, a threat warning may result from discovery of a security breach, and real-time (or near real-time) water quality data might be used as an additional source of information during the threat evaluation. Currently, on-line residual disinfectant monitors provide the most likely source of real-time water quality data. However, data from monitoring stations that measure other parameters (i.e., as part of an early warning system) should be evaluated if available. As with water quality data considered as a threat warning, it is important to evaluate water quality data used during a threat evaluation against a baseline and in light of instrument/method performance (see Section 3.1.6 for additional guidance).

Aesthetic characteristics of water are another potential source of information to support a threat evaluation. This information might be most effectively gathered through a review of consumer complaints at the time of the contamination threat. Section 3.1.7 describes the evaluation of information derived from consumer complaints in the context of a threat warning. Appendix 8.7, contains a "Water Quality and Consumer Complaints Report Form" that may be useful during the analysis of such data in support of a threat evaluation.

Given the limited amount of time available to determine whether or not a contamination threat is 'possible,' there may only be time to conduct a cursory analysis of available water quality or consumer complaint data. The analysis of such data should **begin** at the 'possible' stage and continue through the duration of the threat evaluation.

3.3 Response Actions Considered at the 'Possible' Stage

Once a contamination threat has been deemed 'possible,' relatively low level response actions are appropriate. This section describes two response actions that might be considered at this stage: 1) site characterization and 2) immediate operational response. Site characterization is one of the critical activities in the ongoing threat evaluation and is intended to gather critical information to support the 'credible' stage of the threat evaluation. Immediate operational response actions are primarily intended to limit the potential for exposure of the public to the suspect water while site characterization activities are implemented. An example of an operational response action is hydraulic isolation of a tank by pumping water into the tank or valving out a tank. These actions would generally not affect consumers and thus would generally not require public notification.

The decision to implement these response actions must be made very quickly for the actions to have their desired impact. For example, in order for containment to be an effective operational response, it should be implemented as quickly as feasible after a threat is deemed 'possible.' To facilitate this, the WUERM should be empowered to implement such response actions at the possible stage. However, the plans regarding the use of immediate operational response actions should be shared with utility management and all relevant stakeholders (e.g., the drinking water primacy agency).

3.3.1 Site Characterization Activities

Site characterization is defined as the process of collecting information from the site of a suspected drinking water contamination incident. Site characterization activities include the site investigation, *field safety screening*, rapid field testing of the water, and sample collection. The procedures for performing site characterization and sampling are fully described in Module 3, while this section describes the role of site characterization within the overall context of the threat management process. According to Figure 2-1, if initial information from the threat warning indicates that the threat is 'possible,' site characterization activities are performed to gather additional information that will help to establish whether or not the threat is 'credible.' In this respect, site characterization is both a response action (initiated once a threat is deemed 'possible') and an information source (to help determine whether or not the threat is 'credible').

An overview of the site characterization and sampling process is shown in Figure 2-3. The site characterization process is defined in five primary stages:

1. Customizing the Site Characterization Plan to guide the team during site characterization activities.
2. Approaching the Site to perform an initial assessment of site conditions and potential hazards.
3. Characterizing the Site at which point the team performs their detailed site investigation as well as rapid testing of the water.
4. Collecting Samples for possible delivery to a laboratory for analysis.
5. Exiting the Site after completion of all site characterization activities.

The bracketed boxes on the right side of the figure provide additional detail regarding the activities that are implemented during each stage.

The large arrow along the left side of this figure represents the threat evaluation process, and the interconnecting arrows show the interrelationship between the threat evaluation and site characterization processes. Information gathered to support the initial threat evaluation will also support the development of the customized site characterization plan. As site characterization activities progress, information collected from the site will be used to revise and update the threat evaluation. Likewise, the threat evaluation may impact the course of the site characterization activities.

During the development of a site characterization plan, the incident commander (i.e., the WUERM) and other supporting staff should review available information in order to define the *investigation site* and develop an approach for field testing and sampling. A critical consideration during this planning stage is ensuring the safety of the site characterization team. Accordingly, one objective at this point is to conduct a preliminary assessment of potential site hazards. If there are indicators that hazardous contaminants may be involved, then teams trained in hazardous materials safety and handling techniques, such as HazMat teams, should manage and conduct the site characterization. Steps should also be taken to protect the integrity of any potential evidence at the site (e.g, avoid handling or moving potential evidence). Module 3, Appendix 8.1 provides a "Site Characterization Plan Template" that may be useful in developing a customized site characterization plan.

During the approach to the site, the team should look for any evidence of potential contamination and initiate field safety screening. The purpose of field safety screening is to detect any environmental hazards (i.e., in the air and on surfaces) that might pose a threat to the site characterization team. Field safety screening will be conducted based on preliminary information about the threat and potential site hazards. If signs of a hazard are evident during the approach, the team should halt their approach and immediately inform the WUERM regarding their findings. The WUERM may determine that the threat is 'credible' based on this preliminary information, even before site characterization has been completed. Furthermore, if the investigation or field safety screening indicates any acute hazards in the environment, it will be necessary to immediately evacuate the site. In these instances, teams that are properly equipped and trained should deal with the hazard tentatively identified during screening (e.g., HazMat).

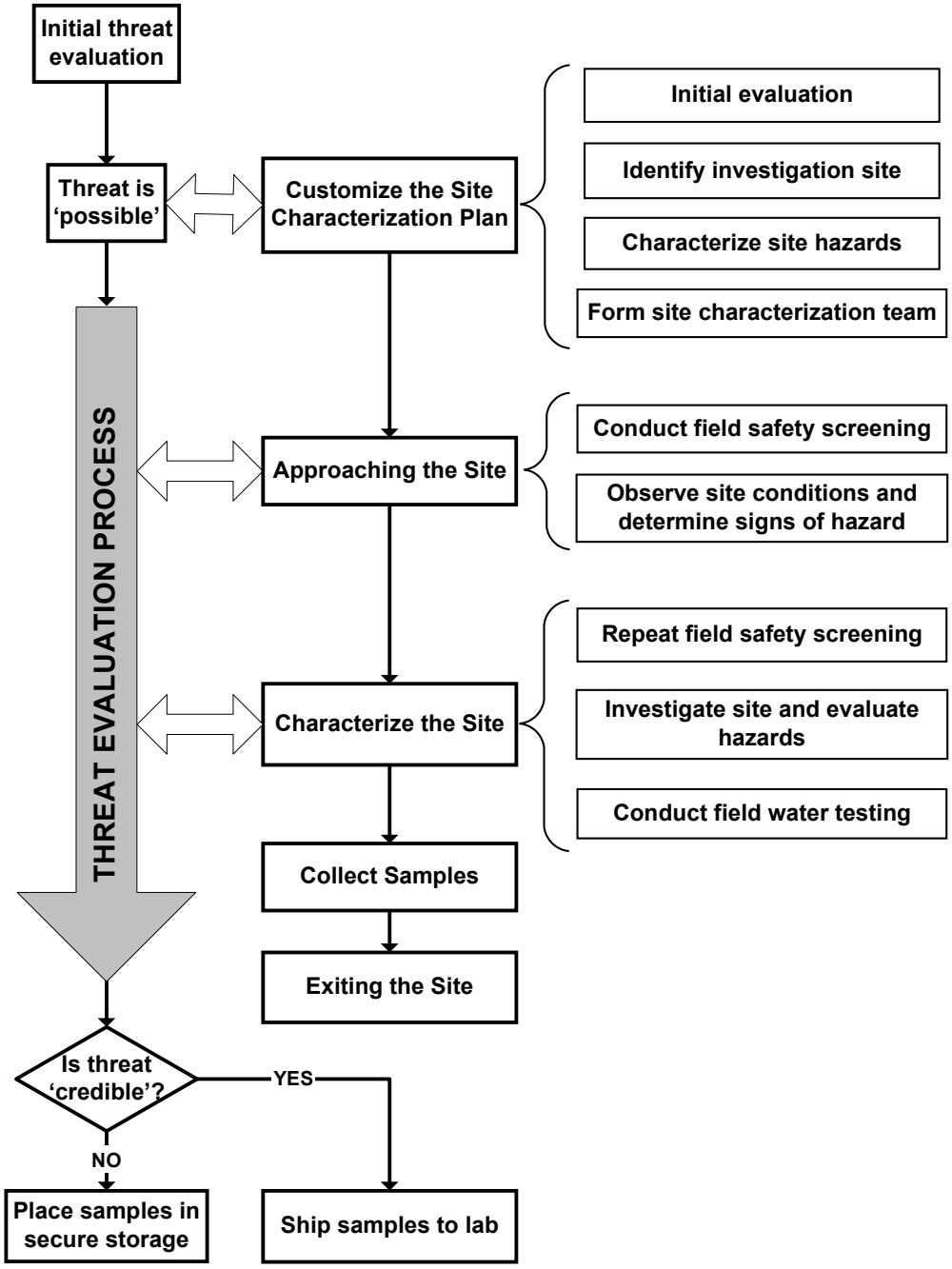


Figure 2-3. Overview of Site Characterization and Sampling Process

In situations where it is deemed necessary to turn over the site to a HazMat team, the WUERM may need to assign a member of the water utility site characterization team to the HazMat team. While it is unlikely that the water utility personnel will be trained in HazMat techniques, they can provide technical advice and guidance to the HazMat responders with respect to water quality, water sampling, and water system components. In some cases the HazMat team may enter the site to perform their hazard assessment and "clear" the site for entry by utility staff.

Once the team has entered the site, they will proceed with the actual site characterization, which includes additional field safety screening, investigation of the site, and rapid field testing of the water. Field safety screening and the site investigation were initiated during the approach and continue when the team enters the site. The primary objectives of rapid field testing of the water include: 1) providing additional information to support the threat evaluation process; 2) providing tentative identification of contaminants that would need to be confirmed in the laboratory; and 3) determining if hazards tentatively identified in the water require special handling precautions.

Following the detailed site characterization, samples should be collected so that they are available for analysis if necessary. Figure 2-3 indicates that the decision to send samples to the laboratory is based on the threat evaluation at the *'credible' stage*. If the threat is deemed 'credible,' the samples should be immediately transported to the laboratory for analysis (see Section 4.2.1 for additional discussion regarding sample analysis). If the threat is not deemed 'credible,' the samples should be stored for a predetermined period of time in case the situation changes and analysis is determined to be necessary.

3.3.2 Immediate Operational Response

The objective of immediate operational response is to minimize the potential for exposure of the public to the suspect water through operational strategies such as containment. These actions are typically suitable for implementation early in the threat management process, assuming that they will have minimal impact on consumers. Furthermore, such response actions may provide the utility with additional time to perform site characterization activities and gather additional information to support the threat evaluation. In general, some form of containment will be the most likely option for an operational response, but other options might be considered as appropriate to a particular situation. Addition guidance on containment can be found in Module 5, Section 4 where containment is considered as a public health response action.

Figure 2-4 provides an overview of the general decision process for implementation of a containment strategy as an operational response to a possible threat. There are three key decision points in the process: 1) Can the area potentially affected by the contaminant be estimated? 2) Is it physically possible to contain the affected area? and 3) Are the impacts of containment on consumers and fire protection minimal? The answers to these questions are influenced by the outcome of the "Consequence Analysis" discussed in Section 2.3.

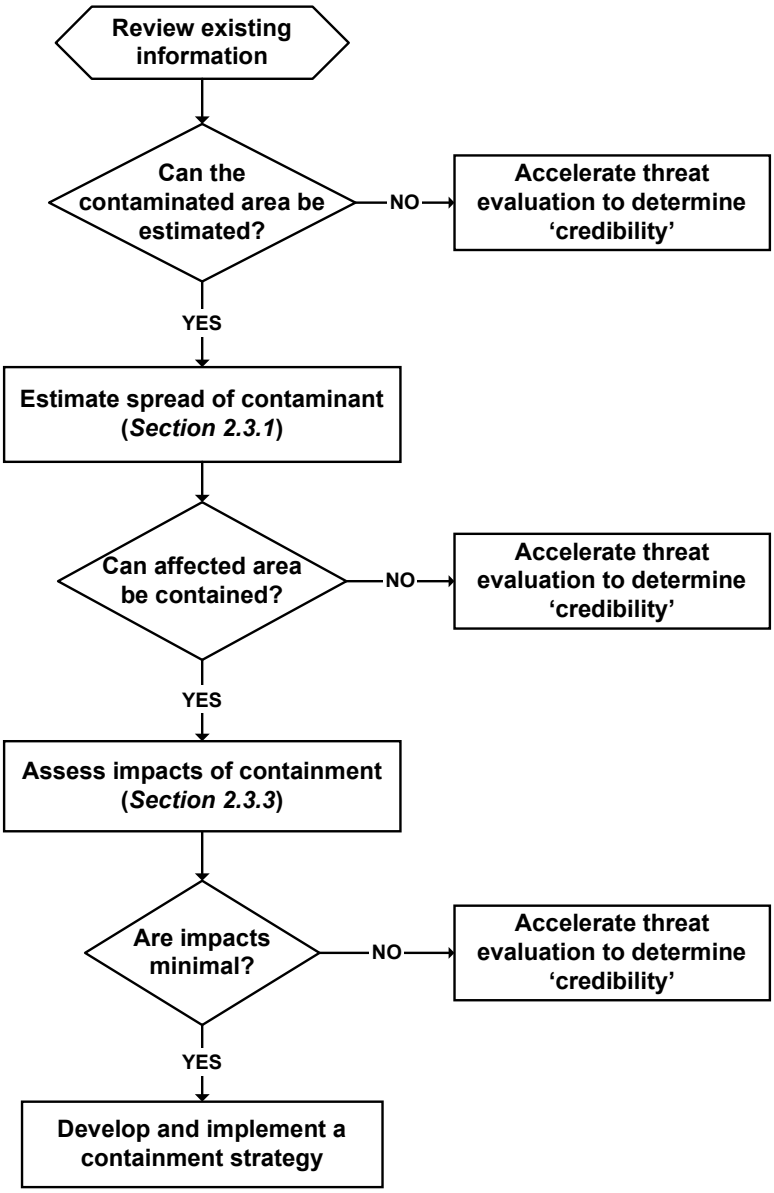


Figure 2-4. Decision Process for Containment as an Operational Response to a 'Possible' Contamination Threat

For containment to be an effective option, the spread of the contaminant must be estimated. This requires knowledge of the suspected location(s) and estimated time(s) of contaminant introduction. These estimates may be derived from the details of the threat warning and other readily available information relevant to the threat. Using the suspected location and time of contaminant introduction as a starting point, the spread of the contaminant through the system can be estimated. Operational information for the system at the suspected location and time may be collected from SCADA, as well as operator knowledge, and will be a valuable resource in estimating the spread of the contaminant. There will generally not be sufficient time to run a hydraulic model for the purpose of estimating the affected area this early in the process. Such

advanced tools may be best used as planning tools where various 'scenarios' can be run to better understand how a contaminant might migrate through a distribution system.

If it is determined that containment is technically feasible and would have minimal impact on the public and on fire protection, then a containment strategy will need to be quickly developed. Utility operations staff will need to engage in both the development and implementation of the containment strategy. Isolation of portions of a system can typically be achieved through hydraulic and/or mechanical means. Hydraulic isolation would typically involve the use of system pumps and pressure zones to contain water within a specific area of the system. Mechanical isolation is achieved through the manipulation of valves, which requires that the valves be accurately mapped and maintained. It is also important to consider how long the isolated area can be kept out of service and plan for alternate routing of water if necessary.

Situations in which containment is likely to be feasible include those in which a specific *contamination site* has been identified and the site can be easily isolated without impacting the normal operation of the system. As an example, some distribution system storage tanks may be isolated using valves without minimal impact on the system pressure. However, there will be many situations in which isolation is not feasible, including situations in which:

- The contamination site is unknown.
- The time of contamination cannot be narrowed down to a reasonable period.
- The extent of the contamination cannot be reasonably estimated.
- The affected area cannot be hydraulically or mechanically isolated.

Furthermore, even if containment is feasible, it may not be practical at the 'possible' stage due to the adverse impacts of isolation on fire protection or sanitation. If containment is determined to be impractical, the threat evaluation should be accelerated to determine whether or not the threat is credible. Once a threat is determined to be credible, expanded response actions might be considered, as discussed in the following section.

4 'Credible' Stage of the Threat Management Process

A water contamination threat is characterized as 'credible' if additional information collected during the investigation corroborates the threat warning, and the collective information indicates that contamination is likely. For example, if the threat warning comes in the form of a security breach and additional signs of contamination are observed during site characterization, the threat would likely be considered 'credible.' While many threat warnings may result in 'possible' contamination threats, only a small percentage of those 'possible' threats are expected to be elevated to 'credible.'

Immediate operational response actions taken once a threat has been deemed 'possible' may decrease the urgency of the situation, but these actions do not constitute resolution of the incident. It is important to move quickly to the next stage of the threat management process to determine whether or not the threat is 'credible' and warrants an elevated response. The target time period for determining whether or not a contamination threat is 'credible' is within **two to eight hours** from the time that the threat is deemed 'possible.' A more precise target time period will depend to some extent on the operational response implemented. If a contaminant strategy was effectively implemented, and there is a degree of confidence that the suspect water did not spread to other parts of the system, there may be more time to make the credibility determination. An example of such a situation is a threat warning resulting from a security breach at a distribution system storage tank that was isolated from the system before the suspect water from the tank had an opportunity to leave the tank and enter the system. On the other hand, if operational response actions cannot be implemented or cannot ensure containment of the suspect water, the threat evaluation process should be accelerated to determine whether or not the threat is 'credible' as quickly as possible.

The decision to elevate a threat from 'possible' to 'credible' is significant since elevated response actions may be necessary to protect public health. These elevated response measures may fall outside of the authority of the WUERM, and the organizations that would be involved in these response decisions would need to be engaged in the threat evaluation process at this stage. This might include water utility management, the drinking water primacy agency, the state/local public health agency, and law enforcement. The person ultimately responsible for determining that a contamination threat is 'credible' is the incident commander, which may not be the WUERM at this stage of the threat management process.

4.1 Information Considered at the 'Credible' Stage

Many of the information resources used to determine that a threat is 'possible' may also prove relevant at the 'credible' stage. Utility information and staff knowledge can aid in the interpretation of new findings from the investigation. Additional water quality data, either real-time or off-line, may be collected and evaluated against baseline data to determine if unusual water quality trends are consistent with the initial data and corroborate the threat. In summary, it is important to view the investigation as a continuum, and the information collected through the 'possible' and 'credible' stages of an investigation should be evaluated in its entirety.

The additional information that might be collected to support the threat evaluation and determine whether or not a threat is 'credible' includes:

- The results of site characterization, including observations from the site investigation as well as results from field safety screening and rapid field testing.
- Summary information derived from an analysis of previous security incidents similar to the current threat warning.
- Information from external sources that is relevant and available in a timely manner.

The following subsections describe each of these information categories in additional detail and discuss how each may be used in support of the threat evaluation process.

4.1.1 Site Characterization Results

In cases in which there is a known or suspected contamination site, site characterization is the focal point of the threat evaluation and potentially provides the most valuable information to support the credibility determination. The findings from site characterization activities should be quickly summarized and provided to the incident commander (which may or may not be the WUERM at this stage) to support the threat evaluation. In Module 3, this summary is referred to as a "Site Characterization Report"; however, it is not intended to be a formal report per se, but may simply be a compilation of the forms completed during site characterization. The information included in the "Site Characterization Report" may include:

- General information about the site.
- Summary of observations from the site investigation including physical evidence (e.g., discarded equipment, containers, etc.) and environmental indicators (e.g., dead animals, dead vegetation, unusual odors, etc.).
- Results from field safety screening and rapid field testing of the water, including any appropriate caveats on the reliability of the results.
- Results of the site hazard assessment.
- Inventory of samples collected and a log of all sampling activities.

The results of field safety screening and rapid field testing of the water warrant special consideration and should be evaluated against baseline data that demonstrates typical variability in the measured parameter. Depending on the parameter monitored, the baseline may vary temporally, spatially, seasonally, or with changing treatment conditions, among other factors. Furthermore, field test results should be evaluated in light of the performance characteristics of the detection equipment such as: the rate of false positive and false negative results; the range in which the instrument or method results are valid; known interferences; and instrument reliability. Deviations from an established baseline that fall within the performance characteristics of the detection equipment may be indicative of contamination. Skill and familiarity with the field testing techniques are required to properly interpret the results. These skills can be reinforced through routine monitoring or exercises with the equipment.

The results of site characterization must be assessed in the context of information previously collected over the course of the threat evaluation. The results of site characterization may corroborate, contradict, or be inconclusive with respect to other information gathered during earlier stages of the incident. **This comprehensive evaluation of information is critical to**

determining whether or not a threat is credible. For example, if the threat warning was a witness account of suspicious activity at a secured location, but no evidence of a security breach was observed during site characterization, the threat would likely be considered 'not credible.' Even though the results of site characterization are critical to the threat evaluation at this stage, it is still important to consider the other available information about the threat, especially if the findings of site characterization are inconclusive.

Another purpose of the site characterization is to conduct a *hazard assessment* of the site, which is an evaluation of the potential presence of immediately dangerous contaminants at the site. Module 3 defines four hazard categories as follows:

- Low hazard – no obvious signs of radiological, chemical, or biological contaminants are present at the site (i.e., in air or on surfaces). Contaminants that may be present in the water are assumed to be dilute and confined to the water.
- Radiological – presence of radiological isotopes or emitters tentatively identified at the site or in the water (i.e., through field safety screening for radioactivity).
- Chemical – presence of highly toxic chemicals (e.g., biotoxins or Schedule 1 chemical weapons) or highly volatile industrial chemicals tentatively identified at the site or in the water that pose a potential risk of exposure through dermal or inhalation routes.
- Biological – presence of pathogens tentatively identified at the site and a potential risk of exposure through dermal or inhalation routes.

The site hazard assessment should incorporate the results of field testing, but not rely exclusively on these results. Observations from the site investigation (e.g., obvious signs of hazards) may be more useful than limited field testing in determining whether or not a site poses an immediate hazard. The findings of the site hazard assessment should be summarized in the 'Site Characterization Report' since they will inform the credibility determination as well as provide direction to subsequent steps of the investigation, such as sample analysis.

4.1.2 Previous Threats and Security Incidents

Information derived from previous threat warnings (i.e., security breaches, phone threats, unusual consumer complaints, etc.) can provide valuable insight regarding the credibility of a current threat. It is equally important to consider those threat warnings that were dismissed as insignificant (e.g., vandalism) as well as those that resulted in an investigation and were deemed 'possible' or 'credible' contamination threats. Such information can be used to corroborate or dismiss a threat; thus it is most appropriate to consider this type of information when evaluating whether or not a threat is 'credible.'

Previous threats and incidents must be documented and catalogued to provide quick access to information that can be used to support a threat evaluation. A comparison between previous incidents and a current threat may indicate whether or not the threat reflects previous patterns and may therefore be deemed 'not credible' (e.g., in the case of repeated vandalism or theft). This documentation could be accomplished through a simple system of filing past reports in an organized and systematic manner. Given the urgency of the threat evaluation process, it is critical that threats be documented and organized when there is time to do so. During emergency

conditions, there will not be time to search through poorly organized or incomplete records in order to further the threat evaluation process.

In addition to a summary of previous threats and security incidents that have occurred at a specific utility, threat information from a regional or national perspective may be of use during a threat evaluation. This information could include results of an analysis of security incidents across the nation, which may be performed by FBI, EPA, AMWA (through ISAC), or AWWA. This type of information might be useful in making general comparisons to the current threat, but will generally not be as relevant as those documented threat warnings that occurred at a specific utility. The types of information that might be available through these and other external sources are discussed in the following section.

4.1.3 Information from External Sources

There are many potential external (i.e., external to the utility) sources of information that may be of value during a threat evaluation. However, as there is insufficient time to identify and pursue new sources during the response to an actual threat, planning is necessary for the effective use of external information sources during a threat evaluation. This planning includes an assessment of the relevance, reliability, and accessibility of each information source prior to the occurrence of a contamination threat. Therefore, it is recommended that a WUERM: 1) identify the information sources that would be used to support a threat evaluation; 2) understand the type of information that the resource might provide; and 3) determine how to access the resource quickly on a 24/7 basis.

The following list provides a summary of external information sources that might be consulted during a threat evaluation. This list is intended to illustrate the value of certain external sources, but is by no means comprehensive. The most relevant information resources will depend on the nature and circumstances of the threat warning, and it is up to the incident commander to apply the information from these various sources in response to a specific threat.

- Drinking Water Primacy Agency: If the Drinking Water Primacy Agency is informed about a contamination threat prior to the credibility determination, they may be of assistance in making this determination. For example, if the primacy agency does track security incidents at water utilities within their jurisdiction, this collective information could be of value when trying to establish the credibility of a threat. Furthermore, the primacy agency may have access to information and expertise for assisting in the threat evaluation process. Also, smaller utilities with limited resources and capability in water security may rely on the primacy agency to perform the threat evaluation.

- EPA: The EPA has a breadth of expertise in drinking water treatment, occurrence and properties of water contaminants, analytical methodology, and remediation of hazardous sites. EPA has also established specific capability in the area of water security in its Water Security Division and National Homeland Security Research Center. Furthermore, EPA's Criminal Investigation Division has experience in the investigation of environmental crimes and links to federal law enforcement agencies. The expertise within EPA can be a valuable resource in responding to a threatened or actual

contamination incident. The best way to access EPA's resources will typically be through the Regional EPA office or the Drinking Water Primacy Agency. Federal expertise, including that from EPA, may also be accessed by calling the National Response Center (NRC) at **1-800-424-8802**. The NRC is the sole point of federal contact for reporting oil and chemical spills and has experts trained to provide assistance in the case of a terrorist threat or incident.

- Law Enforcement Agencies: The expertise of law enforcement agencies (local and State) might be particularly helpful in evaluating the credibility of a contamination threat. They may have knowledge of recent criminal activity in the area that might help establish credibility or support advanced stages of the investigation. It is important to consider that most law enforcement agents have very limited knowledge of drinking water systems, and the WUERM should be available to provide that expertise during the threat evaluation.

- FBI: The FBI may be able to provide support similar to local law enforcement agencies and, in addition, may have access to intelligence information not available to local law enforcement. The focus of the FBI's investigation will be on the criminal or terrorism aspect of the threat, rather than the safety and quality of the water. However, if the FBI determines that the event is credible from a criminal perspective, the threat will likely also be considered credible from a public health perspective.

- Neighboring Utilities: In some cases, neighboring utilities may be a source of information during a threat evaluation. For example, in the case of a threat warning resulting from unusual source water quality, additional insight may be gained by contacting another utility that shares the same source and typically experiences similar water quality. The neighboring utility may be experiencing similar unusual water quality and/or may know the cause.

- Public Health Agencies: Public health agencies may be aware of a significant number of patients showing unusual symptoms or disease through activities such as disease surveillance and reporting. Upon discovering such a trend, the agency may launch an investigation in which they will evaluate how the cases are clustered and search for the cause of the disease. However, in many disease surveillance systems, there is a significant delay between the time that patients begin showing up at hospitals and the time that the public health agency has enough data to observe an unusual trend. Furthermore, there will be a *latency period* between exposure to a contaminant and onset of symptoms, which may range from less than a minute for highly toxic chemicals to over a week for some pathogens.

- 911 Call Centers: 911 call centers may provide consolidated information about unusual signs and symptoms since many members of the public will choose to call 911 for immediate medical assistance. Calls to 911 are even more likely to occur in the case of a chemical poisoning where onset of symptoms is rapid. This information may need to be accessed through law enforcement agencies or an emergency medical service.

- Water ISAC: The Water ISAC is a national resource, available to water-utility subscribers, that serves as a clearinghouse for alerts, warnings, information on drinking water contaminants and other security information released by various agencies. While the information on ISAC may not be immediately relevant to a specific contamination threat at a utility, the collective information on ISAC should create a national picture of the threat level in the water sector and may have information on existing alerts. More detail on the capabilities of the Water ISAC and information regarding how to subscribe can be found at http://www.waterisac.org/.

- Homeland Security Warnings and Alerts: The Department of Homeland Security establishes the national threat level as a general indicator of the potential for terrorist activity and may also issue alerts and warning for specific sectors, such as the water sector. While these warnings and alerts will not be specific to an individual utility, any alerts specific to the water sector or relevant to the circumstances of a particular threat warning may warrant consideration during the threat evaluation.

- Contaminant Information: If a contaminant is named in a threat or tentatively identified during the investigation (i.e., during site characterization), specific information about that contaminant should be consulted to help establish the credibility and potential consequences of the threat. For example, such information can establish whether or not the suspected contaminant is harmful, available, water soluble, stable in water, etc. This information may also support decisions regarding appropriate response actions at the 'credible' stage of the threat management process. A resource for contaminant specific information is the Water Contaminant Information Tool (WCIT). The WCIT is being developed specifically for the water sector and is described in Appendix 8.9. Other sources of contaminant information that might be used in the interim include:
  - http://www.bt.cdc.gov/agent/agentlistchem.asp
  - http://www.cdc.gov/atsdr/index.html
  - http://www.waterisac.org/

4.2 Response Actions Considered at the 'Credible' Stage

The response actions considered at the 'credible' stage may involve more effort and have a greater impact than those considered at the 'possible' stage. This section describes three response actions that might be considered at this stage: 1) sample analysis; 2) continuation of site characterization activities; and 3) public health response. Sample analysis and continuing site characterization are part of the ongoing threat evaluation and are intended to gather information to 'confirm' that a contamination incident did **or** did not occur. Public health response actions are intended to prevent or limit exposure of the public to the suspect water and are more protective and have a greater impact on the public than the operational response actions considered at the 'possible' stage. An example of a public health response action is issuance of a "do not drink" notice.

The incident commander will make decisions regarding actions taken in response to a 'credible' water contamination threat. Due to the elevated level of actions considered in response to a 'credible' threat, responsibility for incident command may be shifted from the WUERM to

another individual or organization at the point when response decisions are made. At this stage, the utility or locality may choose to activate their *Emergency Operations Center* (EOC) to manage the situation, mobilize resources, and institute a more formal incident command structure. Furthermore, the EOC will facilitate a coordinated response among the participating agencies, such as the drinking water primacy agency, state/local public health agency, and local fire and police departments. Activation of the EOC may be full or partial depending on the circumstances.

4.2.1 Sample Analysis

Once a threat has been deemed 'credible,' one of the first steps taken in an effort to confirm a contamination incident is the analysis of samples collected during site characterization. The analytical procedures for confirming the presence of tentatively identified contaminants, or analyzing water samples for unknown contaminants, are presented in Module 4. Given the large number of potential contaminants and the compartmentalized nature of laboratory capability, it will be necessary to make initial decisions regarding the laboratories that will be utilized and the general *analytical approach* that will be used with water samples potentially containing unknown analytes. Note that the presence or suspicion of extremely hazardous substances, as determined through the site characterization, will likely result in other response organizations (e.g., HazMat) becoming involved in the threat management process. These organizations may take responsibility for identifying appropriate laboratories to conduct analyses.

Laboratory selection should be made on the basis of any available information about the threat, the nature of the suspected contaminant, and the hazard assessment performed as part of site characterization. For example, if the site is characterized as a radiological hazard, a radiological laboratory should perform the analytical work. Figure 2-5 shows various categories of laboratories with different analytical capabilities. Laboratories are grouped into two broad categories, chemical and biological laboratories. Chemical labs include general environmental chemistry laboratories, radiological laboratories, and specialty laboratories that may be able to handle exotic contaminants, such as chemical weapons and biotoxins. Biological laboratories include environmental microbiology laboratories and the Laboratory Response Network (LRN) that typically analyze clinical samples for pathogens.

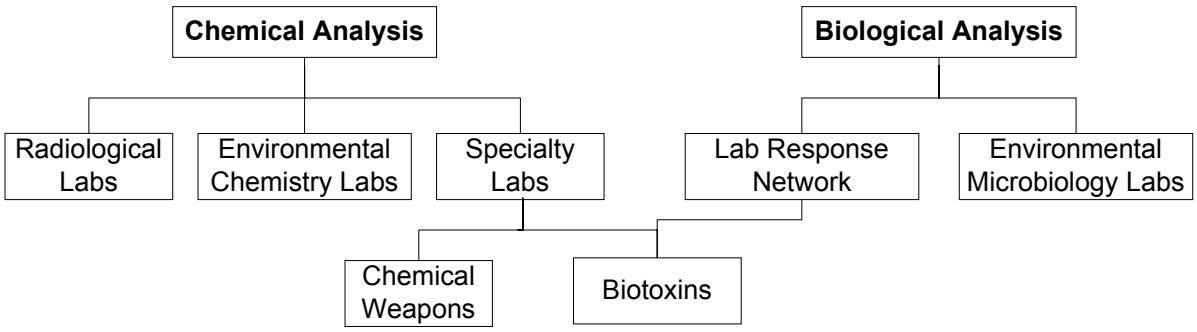


Figure 2-5. Summary of Laboratory Types by Contaminant Class

Once a decision has been made regarding the laboratory(ies) that will be used, the utility and incident commander should work with the laboratory contact(s) to develop an analytical approach for the samples. The approach should be based on all available information about the threat, particularly the results of site characterization. The decision process for developing an analytical approach, which should be planned in advance, is shown in Figure 2-6.

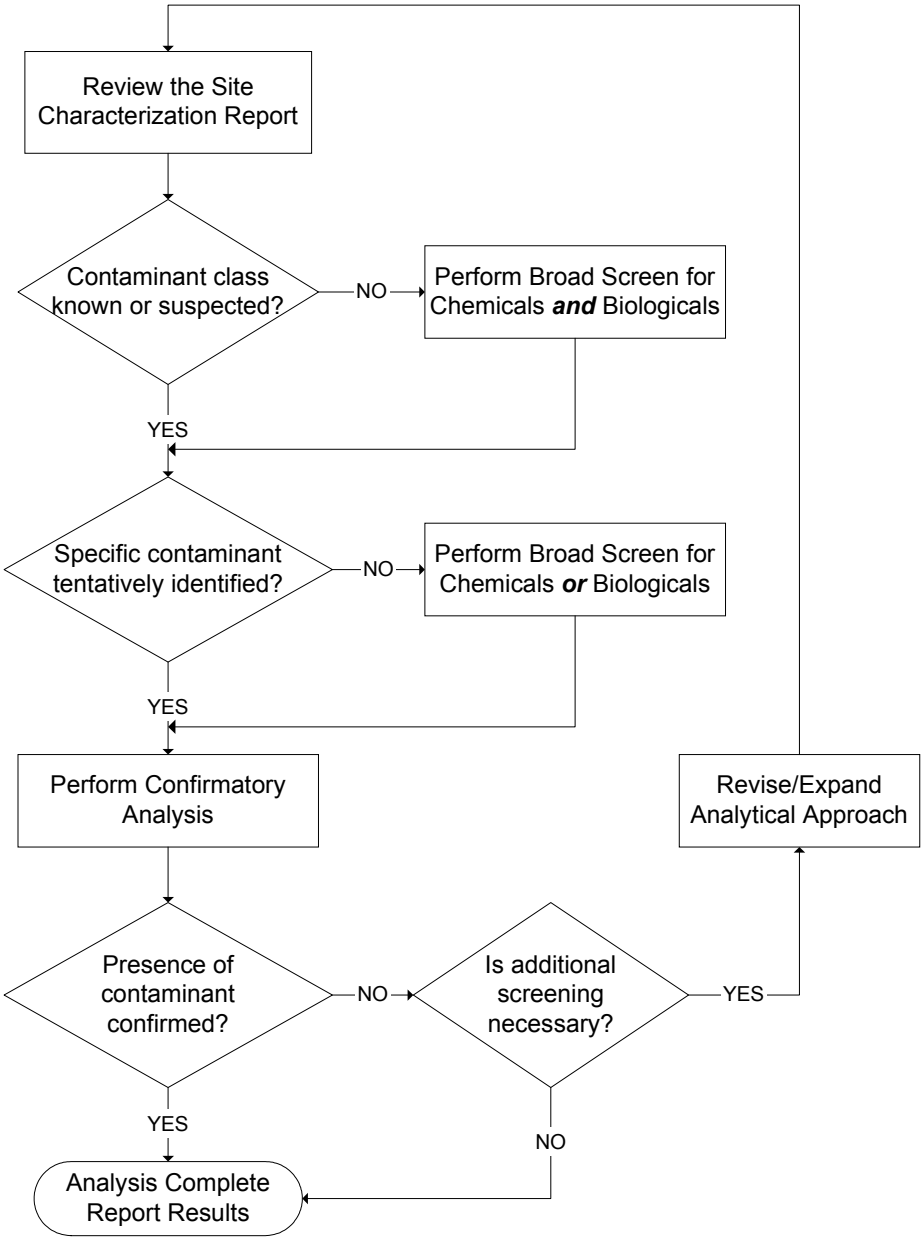


Figure 2-6. Decision Process for the Development of an Analytical Approach for Potentially Contaminated Water Samples

In Figure 2-6, the first decision point in the process is an assessment of whether or not there is sufficient information to make a tentative identification of the contaminant as chemical or pathogen. If this is possible, then an entire class of contaminants is eliminated from consideration, allowing the approach to focus on the tentatively identified contaminant class. If the information is not sufficient to make a determination between chemical and biological contaminants, then the sample may need to be treated as a complete unknown. In this case, it may be necessary to use multiple laboratories (i.e., one lab for chemical analysis and another for pathogen analysis).

The second decision point in Figure 2-6 is based on a tentative identification of the specific contaminant. At this point in the analytical process, the contaminant identity is hypothesized based on available information from the site characterization report or threat warning. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; presumptive positive results for a specific contaminant from field screening; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the causative agent. However, it is important to note that each of these situations has a different level of reliability for the purpose of tentative identification. A tentative identification can be used to focus the analytical approach on confirmation of the specific contaminant or contaminant subclass. For example, tentative identification of a class of pesticides (i.e., organophosphates) may be based on results from a test kit. This information might, in turn, be used to focus the analytical approach on specific pesticides within that class.

The third decision point in Figure 2-6 is based on the results of the analysis used to confirm the presence and concentration of the tentatively identified contaminant. If the presence of the contaminant is analytically confirmed, the contamination incident will also be confirmed. Although not depicted in Figure 2-6, even when the presence of one contaminant has been confirmed, additional analyses may be performed for other contaminants if deemed necessary. The primary purpose of additional laboratory analysis at this point will be further characterization of the contaminated area of the system (see Module 6, Section 4).

If the presence of the tentatively identified contaminant is not verified during confirmatory analysis, the need for additional analytical screening should be considered. Additional screening should be considered since no analytical approach is completely comprehensive. In general, if the threat is still deemed ‘credible’ following negative results from confirmatory analysis, revision to the analytical approach should be considered. Furthermore, it is possible that sampling conducted during site characterization did not capture the contaminated water, and additional sampling may be necessary as discussed in the following section. On the other hand, if the threat is no longer deemed ‘credible’, then additional analysis may be unnecessary.

4.2.2 Continuation of Site Characterization Activities

Site characterization activities initiated in response to a ‘possible’ threat are typically limited to the suspected contamination site with the objective of providing information to support the threat evaluation at the ‘credible’ stage. However, once an incident is deemed ‘credible,’ additional site characterization and sampling activities may be implemented in an attempt to ‘confirm’ a contamination incident. In cases where a ‘credible’ contamination threat is **not** confirmed, the

purpose of additional site characterization and sampling activities will be to verify that the water is safe and support the decision to return to normal operation.

Site characterization activities implemented in response to a 'credible' threat should be planned and coordinated in the same manner as during the 'possible' stage. The scope and extent of site characterization activities at this stage will depend on the available information, and factors to consider include:

- Any information about the identity or nature of the contaminant obtained through laboratory analysis, rapid field testing, or results from the initial site characterization. Such information would help to focus the site characterization activities on the known or suspected contaminant.
- An estimate of the contaminated area through an evaluation of hydraulic information, consumer complaints, water quality data, or other available information. This estimate would help to define the additional locations for site characterization activities.
- Unusual signs or symptoms in the population reported by public health agencies. This information could provide an indication of both the nature and spread of the contaminant. Evaluation of this type of information must consider the latency period between exposure and onset of symptoms.

The available information should help to focus the rapid field testing and sampling activities at this stage. Module 3 contains additional guidance on planning for site characterization activities that is equally applicable to the 'credible' and 'possible' stages of a threat evaluation. In particular, Module 3, Section 3.4 provides some examples that illustrate the transition to follow-on site characterization activities once a threat is deemed 'credible.'

4.2.3 Public Health Response

Like immediate operational response actions, the objective of public health response actions is to minimize the potential for exposure of the public to the suspect water. However, public health response actions are elevated with respect to both the level of protection and the impact on the public. For example, consumers may be instructed to boil water, limit their water uses to activities that do not involve consumption, or not use the water at all. While such measures will provide an increased level of public health protection, they will have a significant impact on consumers. Depending on the duration of these restrictions, it may be necessary to provide an alternate supply of drinking water until the incident is resolved.

Figure 2-7 provides an overview of the general decision process for measures taken to protect public health in response to a 'credible' contamination threat. The first decision point in the process considers containment of the suspect water as a potential public health response action. If containment was implemented at the 'possible' stage as an operational response, the containment strategy should be evaluated to determine if it is adequate to protect public health.

At the 'possible' stage, implementation of containment options was limited by consideration of the impacts of containment on consumers. However, once a threat has been deemed 'credible', expanded containment strategies might also be considered. It may also be appropriate to implement containment strategies and manage the resulting impacts. For example, if there are

consumers within the containment area, it will be necessary to notify them of any restrictions regarding use of their water. In some instances, it may be necessary to provide them with an alternate supply of drinking water.

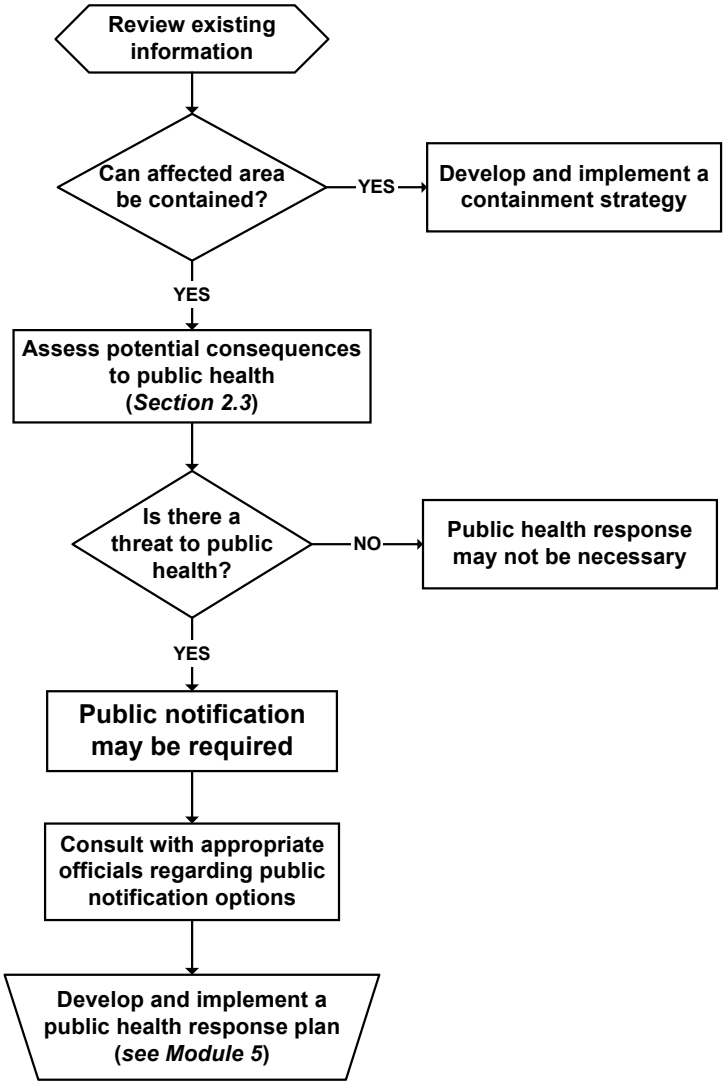


Figure 2-7. Decision Process for Actions taken to Protect Public Health in Response to a 'Credible' Contamination Threat

If containment is deemed inadequate to protect public health, then it is necessary to consider the potential public health consequences of contamination, as discussed in Section 2.3. A "credible threat to public health" results when there is a 'credible' threat **and** the consequences of contamination threaten public health. If it is determined that there is a credible threat to public health, then it may be necessary to notify the public. Furthermore, public notification may be required under the Public Notification Rule (40 CFR Part 141, Subpart Q). Specifically, this rule may require public notification in a "situation with significant potential to have serious adverse

effects on human health as a result of short term exposure" [141.201(b)]. Thus, the utility will need to consult with the drinking water primacy agency, and potentially the public health agency, during the evaluation of public notification requirements and options. Additional guidance regarding public notification and the requirements of this rule can be found in the "Public Notification Handbook" (USEPA, 2002).

Module 5 describes activities related to planning for and implementation of public notifications designed to prevent or limit exposure. Once a decision has been made to notify the public, it is necessary to evaluate the level of notification appropriate for the incident. For example, the level of restrictions on water use that are necessary to protect the public will vary depending on the nature of the contamination. These decisions are influenced by consequence analysis, particularly with regard to the potential health effects of a threat. These potential effects, in turn, are heavily influenced by the identity of the contaminant.

If the contaminant has been tentatively identified at this stage, it may be possible to tailor the public notification to the specific public health risk. For example, if the contaminant only poses a risk through ingestion of contaminated water, a "do not drink" notice may provide a sufficient level of protection. On the other hand, if the identity of the contaminant is unknown, a more restrictive "do not use" notice might be considered. Furthermore, if the public notification places restrictions on the use of the water, it will be necessary to provide a short-term alternate water supply. Of particular concern is the need to maintain fire protection throughout the community. The topics of public notification and alternate drinking water supplies are discussed in detail in Module 5.

5 'Confirmatory' Stage of the Threat Management Process

Confirmation represents the transition from a contamination **threat** to a contamination **incident** and relies on definitive information demonstrating that the water has been contaminated. The most reliable means of confirming a contamination incident is through *analytical confirmation* of the presence of a contaminant. However, under some circumstances, it may be appropriate to confirm a contamination incident in the absence of definitive analytical data. This is particularly true in cases where analytical confirmation may be impractical due to challenges in collecting a representative sample due to uncertainty in the point of contaminant introduction and/or the time that elapsed between the introduction of the contaminant and receipt of the threat warning. In cases where analytical confirmation is deemed impractical, it will be necessary to rely upon the 'preponderance of the evidence' to confirm an incident. A more detailed discussion of this concept is provided below in Section 5.1.

If the threat evaluation yields no conclusive evidence of contamination, then the incident commander may decide that the threat is no longer 'credible.' However, the investigation will have to be sufficiently thorough to demonstrate that the water is safe and the system can be returned to normal operation. Each situation will be unique, and it is up to the judgment and experience of the incident commander and supporting staff to make the determination regarding whether a 'credible' threat is elevated to a 'confirmed' incident or dismissed as 'not credible.'

It may take several days to collect sufficient evidence to confirm a contamination incident, and the required time will depend on the type of information used for confirmation. For example, some microbiological analytical procedures may take several days. The actual amount of time available to confirm the incident will depend on the response actions taken to protect public health once the threat deemed 'credible.'

Due to the magnitude of the effort involved in responding to a confirmed water contamination incident, many organizations will likely be involved in the threat evaluation at this stage. Within the utility, senior managers and the heads of major departments (e.g., operations, water quality, and emergency response) will be involved in this advanced stage of the threat management process. External organizations will likely include the drinking water primacy agency, the state public health agency (if different than the primacy agency), state or local emergency response organizations, and law enforcement agencies. Furthermore, some federal agencies may become involved at this point, and if the governor declares a state of emergency, the Federal Response Plan will become effective and coordinate the federal response (see Module1, Appendix 6.2). While the WUERM will not be responsible for incident command at this stage, it is important for the WUERM to become familiar with the organizations and plans that would be activated in the case of a confirmed contamination incident and to understand the role of the water utility in this situation.

5.1 Information Considered at the 'Confirmatory' Stage

While it is desirable to confirm an incident through laboratory analysis and identification of a particular contaminant, this may not always be feasible. Thus, additional information sources may be considered in an effort to confirm the contamination incident based on a 'preponderance

of evidence.' For example, if there is a security breach with obvious signs of contamination along with unusual water quality and consumer complaints in the vicinity of the security breach, the multiple layers of evidence might be sufficient to confirm a contamination incident. In another situation, additional findings of continued site characterization activities might add to the preponderance of evidence necessary to confirm a contamination incident in the absence of definitive analytical data. The information resources discussed in this section that might support confirmation of a contamination incident include:

- The results from laboratory analysis of samples collected during the initial or continuing site characterization activities.
- The results and observations of continued site characterization activities.
- Information from public health officials, area hospitals, or 911 call centers.
- Information about specific contaminants.
- Targeted information from external sources based on the collective knowledge of the threat.

5.1.1 Analytical Results

Positive identification of a contaminant through sample analysis can confirm a contamination incident and provide the basis for making decisions about public health response actions and remediation activities. Thus, when practical, analytical confirmation should be pursued through a suitable analytical approach as discussed in Module 4. However, all analytical data must be subject to some level of evaluation and interpretation in order to provide meaningful information to support the threat evaluation.

As discussed in Module 4, a report from the laboratory should include the results of all analyses performed, available QA/QC information, and any other information relevant to the interpreting the results. In general, the only analytical results that should be considered at the confirmatory stage of the threat management process are those that have been validated by the laboratory, i.e., the contaminant has been positively identified and/or quantified at the level of concern through the use of accepted analytical methods and QA/QC procedures. If special circumstances warrant consideration of analytical results that have not been validated, it may be necessary to seek laboratory assistance in the interpretation of tentative results. Depending on the analytical methods used, supplementary information provided with non-validated results might include:

- the probability of false negative/false positive results at this stage of analysis;
- method sensitivity, accuracy, and/or precision;
- probability of misidentification;
- quantitative versus qualitative results; and
- the time necessary to confirm the results.

It is important that all of this information be considered when attempting to confirm an incident using data that have not been completely validated.

Furthermore, it is important to consider typical background levels of a particular contaminant during the interpretation of analytical results. However, the availability of background data will likely be limited or nonexistent for many hazardous contaminants. In situations where background data are not available, it may be sufficient to consider occurrence in a more general

sense (i.e., whether the contaminant is known to occur in treated waters). If the general occurrence is unknown, then it may be necessary to evaluate the concentration of the contaminant solely from a public health perspective; specifically, whether or not the contaminant at the levels detected poses any threat to public health.

Interpretation of analytical results for contaminants known to occur in treated drinking water can present unique challenges. For example, chloropicrin and cyanogen chloride are potentially hazardous if present in the water at high concentrations. However, these same compounds are disinfection by-products that result from the reaction of the disinfectant with naturally occurring precursor compounds and thus may occur at very low levels in disinfected drinking water. If low levels of such "normally occurring yet potentially hazardous contaminants" are detected, it must be determined whether these levels represent typical background **or** result from intentional contamination, e.g., the tail of transient contaminant slug or a low-level contamination incident. This uncertainty in the source of the detected contaminant would likely lead to additional sampling and analysis to support the threat evaluation process.

The laboratory should be considered as a potential resource during the interpretation of analytical results. Laboratory staff will have a unique perspective regarding the reliability of the method and interpretation of analytical results as well as substantial experience with the analysis of countless other water samples using the same or similar analytical techniques. Thus, the analyst may have the experience necessary to recognize results that fall within the normal range of occurrence, compared to those more likely to be indicative of an actual contamination incident.

5.1.2 Additional Site Characterization Results

As discussed in Section 4.2.2, site characterization activities may be continued in response to a 'credible' contamination threat to help confirm the incident, or support the decision to return to normal operation if the incident is not confirmed. The focus of continued site characterization would have been influenced by the information already collected through the threat evaluation process; thus, interpretation of the findings may be more straightforward. For example, if unusual water quality results were part of the basis for determining that a threat is 'credible,' additional site characterization activities might be conducted in an effort to confirm the initial findings. Thus, these follow-on site characterization activities will be more focused than the initial site characterization in which there is less information to focus the investigation.

As discussed previously, the results of field safety screening and rapid field testing of the water must be interpreted in the context of background or typical levels, and the reliability of the information must also be considered. Furthermore, the results of additional screening should be compared to the results of the initial screening to determine if they corroborate or contradict the initial results

At the *'confirmatory' stage* of the threat management process, there will likely be results from site characterization activities performed at multiple locations, and these results should be reviewed collectively to explore any potential trends in the data. This may help to build the preponderance of evidence that would be necessary to confirm a contamination incident in the

absence of definitive laboratory analysis. Furthermore, the collective results might provide some indication regarding the spread of the contaminant.

5.1.3 Information from External Sources

Information from external sources can be gathered during the continuing threat evaluation process to support efforts to confirm the incident. At this stage, external resources can be specifically targeted in light of the information already collected to support the threat evaluation. Information from these resources may help to build the preponderance of evidence necessary to confirm an event in the absence of laboratory identification of a contaminant. This information may also support decisions regarding appropriate response actions. The following examples illustrate how external information sources may help to confirm a contamination incident. The other external information sources listed in Section 4.1.3 may also be consulted as appropriate. In any case, it is up to the incident commander and supporting staff to determine how to apply the information from these various sources during the threat evaluation.

- Public Health Sector: In the absence of definitive analytical data to confirm a contamination incident, information from the public health sector may be the next most reliable resource. The occurrence of unusual symptoms in the population or atypical clustering of disease may indicate a potential biological, chemical, or radiological contamination incident. The most immediate source of such information may be through local hospitals and 911 call centers. If there is ample evidence linking these unusual health effects to the drinking water supply, that may be sufficient to confirm the contamination incident. However, water is only one possible source of the contaminant and, in many cases, will not be the primary focus of the public health investigation. The state or local public health agency would typically be the lead agency in the public health investigation and would likely confirm the source of the incident.

- Law Enforcement Agencies: Local and federal law enforcement agencies will probably not be as critical to the 'confirmatory' stage of the investigation as they are at the 'possible' or 'credible' stages. Nonetheless, these agencies will likely still be engaged in the evaluation of a 'credible' threat, particularly as they continue the criminal aspect of the investigation. In particular, they may discover crucial evidence or apprehend a suspect that could help to confirm whether or not the water has been contaminated. Such information would typically not provide definitive analytical confirmation (i.e., it may not reveal the identity of the contaminant); however, it may support confirmation based on a preponderance of evidence. In any case, it is important that the utility remain engaged with law enforcement throughout the investigation.

- Contaminant Information: At the confirmatory stage of the threat management process, information about specific contaminants becomes particularly important. In cases where the contaminant has been identified through laboratory analysis or other definitive means, such information is critical for assessing potential impacts to public health resulting from various routes of exposure to the contaminant. Furthermore, this information will be used to make decisions regarding suitable remediation options. On the other hand, if the contaminant has not been identified, specific information on a number of potential

contaminants might be used in conjunction with other available information in an attempt to narrow down the number of contaminant candidates. For example, if information from site characterization activities indicates that the contaminant impacts water quality in a certain manner (i.e., consumes free chlorine or imparts a certain odor to the water), the contaminant specific information may facilitate tentative identification of a contaminant and inform the analytical approach that would be used in an attempt to positively identify the contaminant. A resource for contaminant specific information is the Water Contaminant Information Tool (WCIT). The WCIT is being developed specifically for the water sector and is described in Appendix 8.9. The WCIT is currently under development, and other sources of contaminant information that might be used in the interim include:

- http://www.bt.cdc.gov/agent/agentlistchem.asp
- http://www.cdc.gov/atsdr/index.html
- http://www.waterisac.org/

5.2 Response Actions Considered at the 'Confirmatory' Stage

Once a contamination incident has been confirmed, it will be necessary to move into full response mode. At this point, the EOC may be fully activated in order to support an effective and coordinated response. Other organizations that may be actively engaged in the response include: the drinking water primacy agency, the public health agency, response agencies, and law enforcement. All of these participating organizations will likely be coordinated under existing incident command structures designed to manage emergencies at the state or local level. One agency will be designated as a lead agency and will be responsible for incident command. If federal agencies are involved in the response, their roles and responsibilities are established by the Federal Response Plan. States and local entities have likely established their own response plans that would be in effect if the incident were managed at that level. In any case, the utility will still have a role in the implementation of full response actions; however, they will generally act in a technical support role.

Figure 2-8 illustrates the actions that might be taken in response to a confirmed contamination incident. The process begins with an evaluation of available information about the incident, which should include identification of the contaminant. Effective implementation of response actions at this stage does depend on positive identification of the contaminant and knowledge of contaminant properties. In particular, the appropriateness of various public health protection strategies and selection of treatment technologies will depend on the nature of the specific contaminant. Due to the potential impact of response actions considered at the 'confirmatory' stage, decision makers may question whether or not the incident has indeed been confirmed if a contaminant cannot be detected in the water. Therefore, it is vital to perform a thorough investigation in order to have confidence in any decisions about response actions. This is especially true if response actions are implemented on the basis of a "preponderance of evidence" rather than analytical confirmation.

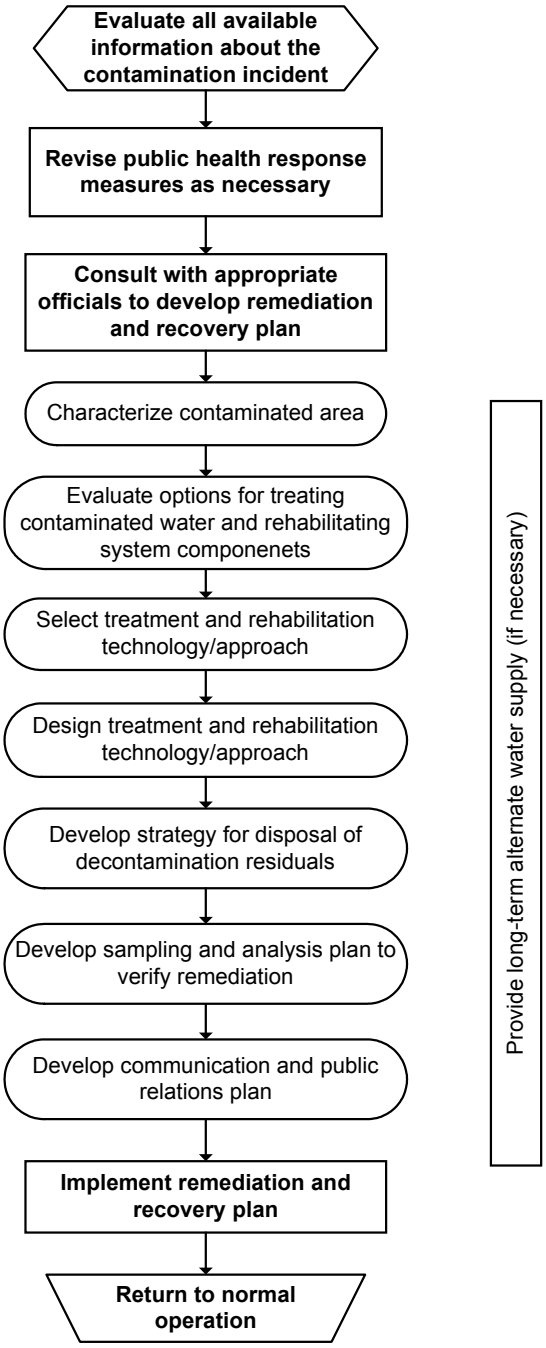


Figure 2-8. Overview of Response to a Confirmed Contamination Incident

Following the initial review of available information about the incident, the public health response measures already implemented should be reassessed and revised if necessary. This process might include revisions to containment strategies or public notifications. This is particularly important if the contaminant has been identified and/or the affected area better characterized following the initial implementation of public health response measures. Once the

immediate public health crisis is under control, efforts will likely focus on remediation and recovery.

Remediation and recovery activities will likely be planned and implemented by a number of agencies, and the first step of the process is to establish the roles and responsibilities of each organization. The elements of the remediation and recovery plan are called out in Figure 2-8 as ovals. Characterization of the contaminated area includes an evaluation of contaminant properties, contaminant concentration profiles, and characteristics of the impacted area. This information is essential to the evaluation of options for treating the contaminated water, remediation of contaminated system components, and disposal of decontamination residuals. The plan should also consider options for supplying alternate drinking water to customers over the duration of the project. Sampling and analysis will be necessary to monitor the progress of treatment and remediation and to ensure that the system is cleaned to acceptable levels by the end of the project. Communications and public relations will be integral to regaining consumer confidence and thus should be considered in the plan as well. Upon successful completion of the remediation effort, the system can begin the process of returning to normal operation. Module 6 describes the remediation and recovery process in detail.

6 Contamination Threat Management Matrices

The previous sections described the three stages of a threat evaluation: 'possible,' 'credible,' and 'confirmatory.' This section compares and contrasts how the information, evaluation, and response options vary as the threat evaluation progresses through the three stages for each of the different types of threat warnings discussed in Section 3.1. For each of these threat warnings, a "contamination threat management matrix" is presented. Each matrix is a tabular summary that lists the following at each stage of the threat evaluation:

- Information considered during the threat evaluation.
- Factors considered during the threat evaluation.
- Potential notifications unique to specific stage of a particular threat warning.
- Potential response actions.

These matrices are necessarily generic and are provided as examples of how the threat management framework described in the previous sections of this module might be applied to specific threat warnings. As part of their planning, users are encouraged to tailor these matrices to their specific circumstances as well as consider threat warnings other than those listed. Furthermore, threat matrices can be developed for more detailed threat scenarios, for example:

- A security breach at a tank that can be isolated from the system.
- A security breach at an uncovered finished water reservoir that cannot be isolated.
- A security breach discovered by an alarm.
- A security breach discovered by utility staff during routine inspection.

Such customized "contamination threat management matrices" could be used as an aid in the development and refinement of ERPs. For example, the completed matrices may indicate the type of response actions that would need to be planned in advance. The customized matrices might also be incorporated into the utility's site-specific "Response Guidelines" and used as a quick reference during the response to a contamination threat.

6.1 Security Breach

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Location of security breach. • Time of security breach. • Information from alarms. • Observations when security breach was discovered. • Additional details from the threat warning.	• Results of site characterization at location of security breach. • Previous security incidents. • Real time water quality data from the location of security breach. • Input from local law enforcement.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Was there an opportunity for contamination? • Has normal operational activity been ruled out? • Have other "harmless" causes been ruled out?	• Do site characterization results reveal signs of contamination? • Is this security breach similar to previous security incidents? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement agencies.	• Drinking water primacy agency. • State/local public health agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area. • Initiate site characterization. • Estimate spread of suspected contaminant. • Consult external information sources.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Security breaches may be the most common type of threat warning encountered by a utility since they may result from trespassing, vandalism, theft, or failure to re-secure facilities following legitimate activities. The purpose of the threat evaluation under this scenario is to distinguish between these more frequent, yet relatively harmless security breaches, and those few that might be considered 'credible' contamination threats.

At the 'possible' stage of the threat evaluation under this scenario, information about the security breach will be available. Specifically, the location of the security breach will be known, which will likely be established as the initial investigation site. Other information may be available from alarms (including surveillance footage), which may help to establish the time of the security breach. The evaluation at this stage should consider whether or not there was an opportunity for contamination at the site of the security breach. Furthermore, "normal" activity should be considered and investigated at this stage as potential reasons for the security breach (e.g., was a utility crew recently at the site and potentially forgot to re-secure the area?). If the threat of contamination is considered 'possible,' law enforcement agents should be contacted since the security breach may be a result of criminal activity (e.g., criminal trespassing). Potential response actions to a 'possible' threat may include isolating areas of the system that

could be affected, initiating site characterization activities to collect more information in support of the threat evaluation, and initiating the process to estimate the spread of the suspect water through the system.

Information that may be available at the 'credible' stage includes the results of site characterization, an assessment of previous security incidents, real-time water quality data in the area of the security breach, and an assessment of the threat by law enforcement. The evaluation at this stage will consider whether or not signs of contamination were discovered during site characterization, including unusual results from field testing or unusual observations during the site investigation. Consideration should also be given to whether or not the new information available at this stage corroborates the information about the threat. The drinking water primacy agency may be contacted during the 'credible' stage to assist with the threat evaluation and make decisions regarding response actions. (Note: the point at which a primacy agency is notified following discovery of a security breach, or other threat warning, should be consistent with any primacy agency requirements.) The public health agency (if different from the primacy agency) should also be notified if there is a potential threat to public health, particularly since this agency will be able to gather information regarding unusual symptoms in the population and should be involved in any decisions regarding actions taken to protect public health. If the threat is determined to be 'credible,' response actions may include measures to limit or prevent exposure of the public to the suspect water, such as public notification. Actions taken to continue the investigation at this point may include analysis of samples collected from the site, continued site characterization activities, and an analysis to estimate the spread of the contaminant.

The new information available at the confirmatory stage may include the results from laboratory analysis, including QA/QC data to support the interpretation of the results. If a specific contaminant is identified, then additional information about that contaminant can be used to further evaluate the nature of the threat as well as implications to public health. The findings of continued site characterization activities may also help to confirm the incident. The basis for confirming a contamination incident can be analytical results that identify a specific contaminant or other definitive evidence that a contaminant is present in the water. If a contaminant has been identified, consideration should be given to the health effects associated with exposure to that contaminant. It may be necessary to revise the sampling and analysis plans if a contaminant was not positively identified through laboratory analysis but the threat is still deemed 'credible.' Upon confirmation of a contamination incident, a number of agencies that will support the response will need to be notified. Response actions potentially initiated once a contamination incident has been confirmed include characterization of the contaminated area, revision to public health protection measures, provision of alternate water supplies, and planning for remediation and recovery activities.

6.2 Witness Account

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Location of the suspicious activity. • Witness account of the suspicious activity. • Additional details from the threat warning.	• Additional information from the witness. • Results of site characterization at location of suspicious activity. • Previous security incidents. • Real time water quality data from the location of suspicious activity. • Input from local law enforcement.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Was there an opportunity for contamination? • Is the witness reliable? • Has normal operational activity been ruled out? • Have other "harmless" causes been ruled out?	• Do site characterization results reveal signs of contamination? • Is the suspicious activity similar to previous security incidents? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement.	• Drinking water primacy agency. • State/local public health agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area. • Initiate site characterization. • Estimate spread of suspected contaminant. • Consult external information sources. • Interview witness for additional information.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

From the perspective of the threat management process, a threat triggered by a witness account is similar to one triggered by a security breach. One of the few significant differences is the use of information collected directly from the witness throughout the evaluation, particularly during the 'possible' and 'credible' stages of the threat evaluation. As discussed in Section 3.1.2, the reliability of the witness must be considered when making these determinations, and additional evidence collected during the investigation should be evaluated to determine whether or not it corroborates the witness account. In some cases, access to a witness may be restricted by law enforcement agencies, and a direct interview may not be possible. If this is the case, the incident commander should work with law enforcement and make them aware of the type of information that is needed to support the utility's threat evaluation.

6.3 Direct Notification by Perpetrator

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Transcript of phone (or written) threat. • The who, what, where, when, and why of the threat. • Additional details from the threat warning. • Vulnerability assessment.	• Law enforcement assessment. • Primacy agency assessment. • Previous threats at this utility or other utilities. • Results of site characterization at selected investigation sites. • Real time water quality data. • Reports from ISAC, EPA, etc.	• FBI assessment. • Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Is the threat feasible? • Has the water already been contaminated? • Is the location known or suspected? • Is the identity of the perpetrator known or suspected? • Have there been personnel problems at the utility?	• Do site characterization results reveal signs of contamination? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat? • Does the primacy agency consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement. • Drinking water primacy agency.	• FBI. • State/local public health agency. • EPA Criminal Investigation Division.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area if identified in the threat. • Identify sites and initiate site characterization. • Consult external information sources. • Gather information from law enforcement assessment.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites. • Estimate spread of suspected contaminant.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Threats to contaminate the water made via direct notification by a perpetrator need to be taken seriously, especially since the mere act of making such a threat is a criminal act. However, the majority of such direct threats are hoaxes that may be intended to cause panic or disruption, gain attention, or meet some personal objective such as revenge. Thus, the focus of the threat evaluation for this type of threat warning is to identify any credible threats amongst the larger number of hoax notifications. In any cases, such threats should generally be reported to law enforcement and the drinking water primacy agency.

A key source of information that may support the threat evaluation under this scenario is provided directly by the perpetrator making the threat, and forms are included in Appendices 8.5 and 8.6 to document phone and written threats, respectively. In the case of a phone threat, it is important to collect information from the caller regarding the threat to support the threat evaluation. Similarly, a written notification should be carefully reviewed for details about the

threat. Additional information collected throughout the investigation should be evaluated against the details of the threat notification. If the additional information collected during the investigation corroborates the details of the threat notification, then the threat is more likely to be considered 'credible.' Furthermore, law enforcement agencies will likely assess the credibility of the threat from a criminal perspective and thus directly support the threat evaluation process. If law enforcement identifies potential suspects, they may take custody of and interview the suspect, and the information gathered during the interview of suspects may be of value during the threat evaluation.

One of the potential challenges in managing a threat triggered by direct notification from a perpetrator is identification of an investigation site that will be the focus of site characterization activities. Unless a location is named in the threat, it will be necessary to use other information, such as that derived from vulnerability assessments or unusual water quality data/consumer complaints, to identify investigation sites. Additional guidance on the selection of investigation sites for site characterization is provided in Module 3.

6.4 Notification by Law Enforcement

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Law enforcement report. • The who, what, where, when, and why of the threat. • Additional details from the threat warning. • Vulnerability assessment.	• Law enforcement assessment. • Previous security incidents. • Results of site characterization at selected investigation sites. • Real time water quality data. • Reports from ISAC, EPA, etc.	• FBI assessment. • Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• How did the threat warning come to law enforcement? • Is the threat feasible? • Has the water already been contaminated? • Is a specific location targeted?	• Do site characterization results reveal signs of contamination? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat? • Does the primacy agency consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Drinking water primacy agency.	• FBI • State/local public health agency.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area if known. • Identify sites and initiate site characterization. • Work with law enforcement to assess threat credibility. • Consult external information sources.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites. • Estimate spread of suspected contaminant.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Notification of a potential contamination threat by law enforcement may originate from a witness account (reported to a law enforcement agency) or direct notification by the perpetrator, and thus a notification by a law enforcement agency will have some commonalities with these other types of threat warnings. A threat warning coming directly from a law enforcement agent has an initial level of credibility due to the source. However, the specific details should be further evaluated by the WUERM and supporting staff to determine if the threat is indeed possible. Law enforcement agencies will need to rely upon the expertise of drinking water professionals, including those from the utility and primacy agency, to evaluate the threat from the perspective of water quality and public health.

Information used to support the threat evaluation during the 'possible' and 'credible' stages may be derived from the law enforcement agency report and any specific details about the threat that are available. Additional information collected throughout the investigation should be evaluated against the details provided by law enforcement or gained from interviews with witnesses or suspects. Furthermore, any additional information collected should be immediately reported to

law enforcement to aid their ongoing investigation. If the additional information collected during the investigation corroborates the details of the threat warning, then the threat is more likely to be considered 'credible.' The utility will need to work closely with law enforcement agents throughout the threat evaluation in order to determine whether or not the threat is 'credible' and warrants a response.

In some cases, the information about the threat may be sufficient to identify an investigation site. For example, if the notification is a result of a witness account in which suspicious activity was observed at a particular location, it will likely be selected as an investigation site. However, in situations where a site has not been identified, it will be necessary to use other information, such as that derived from vulnerability assessments or unusual water quality data/consumer complaints, to identify investigation sites. Additional guidance on the selection of investigation sites for site characterization is provided in Module 3.

6.5 Notification by News Media

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Details of media report. • The who, what, where, when, and why of the threat. • Additional details from the threat warning. • Vulnerability assessment.	• Additional details from media. • Law enforcement assessment. • Previous security incidents. • Results of site characterization at selected investigation sites. • Real time water quality data. • Reports from ISAC, EPA, etc.	• FBI assessment. • Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• How did the threat warning come to the media? • Is the threat feasible? • Has the water already been contaminated? • Is a specific location targeted?	• Do site characterization results reveal signs of contamination? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat? • Does the primacy agency consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement. • Drinking water primacy agency.	• FBI • State/local public health agency.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area if known. • Identify sites and initiate site characterization. • Contact news media for additional details. • Consult external information sources.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites. • Estimate spread of suspected contaminant.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

In some cases, the news media may be alerted to a threat before the utility. If the threat is generic, the utility may only be able to collect additional information from the media, primacy agency, EPA, ISAC, and other sources to determine if the threat is at all relevant to the specific utility. In the absence of any specifics, the utility may be able to do nothing more than increase vigilance.

If a threat reported by the news media has elements that are specific to a utility, additional information should be collected from the media to help establish whether the threat is 'possible' or 'credible'. Furthermore, the media's information source should be contacted directly if at all possible. It may also be prudent to contact law enforcement agencies early in the process to help determine whether or not the threat is 'possible' or 'credible.' Other than the involvement of the media as an information resource, a threat triggered by notification from news media may be handled in a manner similar to those triggered by other notifications (e.g., directly from the perpetrator or from a law enforcement agency). Additional information collected throughout the investigation should be evaluated against the details of the threat warning. If the additional

information collected during the investigation corroborates the details of the media report, then the threat is more likely to be considered 'credible'.

The media notification may or may not provide information necessary to identify an investigation site. If the media report contains no information about a potential contamination site, it will be necessary to use other information, such as that derived from vulnerability assessments or unusual water quality data/consumer complaints, to identify investigation sites. Additional guidance on the selection of investigation sites for site characterization is provided in Module 3.

6.6 Unusual Water Quality

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Unusual water quality data. • Baseline water quality data. • Real time water quality data. • Operational information corresponding to the time of the unusual water quality.	• Results of site characterization at selected investigation sites. • Previous threat warnings triggered by water quality. • Contaminant information. • Reports of consumer complaints.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Is the unusual water quality significantly different from an established baseline? • Could operational changes be the cause? • Could changes in source water quality be the cause? • Are there similar results at other monitoring locations?	• Do site characterization results reveal signs of contamination? • Is this unusual data substantial different from other water quality episodes? • Is the unusual data indicative of a specific contaminant? • Are the unusual water quality clustered in a specific area? • Are there any unusual consumer complaints in the area?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility.	• Drinking water primacy agency. • State/local public health agency. • Local law enforcement. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Identify sites and initiate site characterization. • Begin analysis of available water quality data. • Investigate unusual consumer complaints. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

A threat warning arising from unusual water quality data is **significantly different** from the other threat warnings previously discussed and thus should be handled differently during the threat evaluation. In determining whether or not the threat is possible, it is necessary to evaluate the anomalous data relative to an established baseline. Furthermore, it is important to consider operational conditions, or potential impacts from changing source water quality or distribution system blending as possible explanations for the unusual water quality. If the unusual water quality data is determined to be significantly different from the baseline, and cannot be explained by other factors, then the threat of contamination should be considered a possibility. In order to proceed with the threat evaluation in a timely manner, the supporting information, such as baseline water quality data, must be summarized in a useful, predetermined format that facilitates a rapid assessment of the suspect water quality data.

Presumably, the unusual water quality data will be associated with a particular location in the system, which will help in the identification of investigation sites that will be the focus of site characterization activities. At this stage of the incident, it is important to verify the anomalous water quality data through additional testing using independent equipment. For example, if an incident was triggered by a rapid decrease in the free chlorine residual, as detected by online electrochemical monitors, additional testing could be performed with colormetric field kits to confirm the results. Additional rapid field testing might also help to determine the bounds of the affected area. Furthermore, additional data collected during the investigation should be evaluated to determine whether or not it corroborates the unusual water quality data. Specific information about particular contaminants should be considered at the 'credible' stage as it might be used to identify potential contaminants that would impact the water quality parameter with anomalous readings. For example, contaminants with acidic functional groups might result in reduced pH.

The investigation of unusual water quality will likely remain within the utility until sufficient information has been gathered to indicate that there is a credible contamination threat. Water quality changes constantly due to a number of complex and interrelated factors, and it is appropriate that most of these water quality episodes be investigated within the utility. However, it is equally important to recognize a significant, unusual, and unexplained change in water quality and investigate the cause. If over the course of the investigation, corroborating evidence is found to indicate a 'credible' contamination threat, then additional notification outside of the utility may be appropriate.

6.7 Consumer Complaint

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Compilation of consumer complaints, including geographic distribution. • Recent water quality data that may be associated with complaints. • Operational information corresponding to the time of the unusual complaints.	• Results of site characterization at selected investigation sites. • Summary of historic consumer complaints. • Results of consumer interviews. • Contaminant information.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Are the complaints unusual? • Could operational changes be the cause? • Could changes in source water quality be the cause? • Are the complaints clustered in a specific area? • Are complaints from habitual complainers?	• Do site characterization results reveal signs of contamination? • Are other consumers in the area experiencing similar water quality? • Are the unusual complaints significantly different from typical complaints? • Are the complaints indicative of a specific contaminant? • Is there anything unusual about the water quality in the area?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility.	• Drinking water primacy agency. • State/local public health agency. • Local law enforcement agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Identify sites and initiate site characterization. • Begin analysis of available water quality data. • Interview consumers in area with high numbers of complaints. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

If a utility has a system for tracking consumer complaints, then there is the potential that a high or unusual incidence of consumer complaints could serve as a warning of a possible contamination incident. This is especially true for chemical contaminants, which, depending upon the concentration, may impart a strong odor/taste or discolor the water. In many respects, a threat warning resulting from consumer complaints is similar to one resulting from unusual water quality, particularly when one considers that consumer complaints are simply a surrogate indicator for the aesthetic qualities of drinking water. Furthermore, consumer complaints must be evaluated against baseline information about complaints in order to determine if they are indicative of a 'possible' contamination threat. Other factors that might impact aesthetic water quality, or consumer complaints, should also be considered when determining whether or not the

threat is 'possible.' For example, operational changes or normal source water events, such as algal blooms, could be the cause of the complaints.

In order for consumer complaints to be an effective trigger, a utility must have a system in place that responds to consumer complaints in a timely fashion and have an established communication link to the WUERM. Furthermore, an effective system would be operational 24/7 with staff trained in recognizing contaminant characteristics such as unusual odors and able to characterize complaints by type and location.

If there is a geographic clustering of complaints, this will assist in the identification of investigation sites that will be the focus of site characterization activities. Available online water quality data and rapid field testing results should be evaluated to determine whether or not the information corroborates or explains the aesthetic changes in the water. Furthermore, other customers in the same area might be questioned regarding the aesthetic qualities of their drinking water. If the additional information collected during the evaluation indicates that contamination is likely, then the threat will likely be deemed 'credible.'

6.8 Public Health Notification

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Details of notification from public health sector. • Symptoms of disease and causative agent, if known. • Contaminant information.	• Geographic distribution of disease or death. • Recent water quality and operational data. • Reports of consumer complaints. • Contaminant information.	• Results of site characterization at selected investigation sites. • Results of sample analysis. • Contaminant information. • FBI assessment.
Evaluation	• Why is water under investigation as a possible source? • Are the reported symptoms consistent with exposure to the contaminant via water? • If causative agent is known, is it stable in water?	• Is the geographic pattern of exposure consistent with exposure to contaminated water? • Is there a recent occurrence of unusual water quality data or consumer complaints? • Does additional information about the potential contaminant indicate water as a potential source?	• Has the public health agency concluded that water is the cause of the disease or deaths? • Did sample analysis detect the causative agent? • Was another contaminant detected during sample analysis that could be the cause of the disease or deaths?
Notifications	• Notifications within utility. • State/local public health agency. • Drinking water primacy agency.	• FBI. • Local and State law enforcement agencies.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Consult with public health agency and primacy agency. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Identify sites and initiate site characterization. • Analyze samples.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Notification from public health regarding a potential water contamination incident is unique in that individuals have been exposed to a harmful substance resulting in illness, disease or death in the population. The threat evaluation in this case may be part of a larger epidemiological investigation to determine the cause of disease. From a utility perspective, the first step will be to evaluate whether or not the drinking water is a possible source of the harmful contaminant. It is critical that the utility work with the appropriate public health officials from the outset, since these officials will likely have information critical for the evaluation. For example, they may know or suspect the causative agent based on clinical information. This knowledge, in conjunction with information about the properties of the contaminant, may indicate whether or not contaminated water is even a possibility. For example, if the causative agent is known to immediately decompose upon exposure to water, then the possibility of contaminated water might be dismissed.

If water is considered a possible carrier for the contaminant, then further investigation should be conducted to determine if water is the most likely carrier of the contaminant (i.e., analogous to

the 'credible' stage of the threat evaluation). Information that may help to make this determination will include additional findings from the larger epidemiological investigation, geographic distribution of exposure, recent water quality and operational data, and reports of consumer complaints. If this additional information indicates that water contamination is likely, response actions would likely include public notification to limit further exposure as well as sampling for the suspected contaminant.

The sampling plan developed at this point may start with information about the geographic distribution of exposure; however, consideration must be given to the latency period of the disease, which could be from minutes to weeks, as well as the travel time within the system. The objectives of sampling and analysis at this point would include: 1) confirming the presence of the contaminant in the water; 2) determining if the contaminant is still present; and 3) determining the area affected. If water contamination is confirmed, and the contaminant is still present in the system, it will be necessary to begin planning for remediation and recovery efforts. If the contaminant is not found, extensive sampling would likely be necessary to demonstrate that the contaminant is indeed absent from the system.

7 References and Resources

References and information cited or used to develop this module are listed below. The URLs of several sources are cited throughout the text. These URLs were correct at the time of the preparation of this document. If the document is no longer available at the URL provided, please search the sponsoring organization's Web site or the World Wide Web for alternate sources. A copy of referenced documents may also be provided on the CD version of this module, although readers should consult the referenced URL for the latest version.

AWWARF, 2002. Online monitoring for drinking water utilities. Editor, Erika Hargesheimer, AWWA Research Foundation and CRS PROAQUA, American Water Works Association, Denver, CO; ISBN 1-58321-183-7.

FEMA Emergency Management Institute. http://training.fema.gov/EMIWeb/IS/crslist.asp.

U.S. Army Center for Health Promotion and Preventative Medicine, 2003. "Drinking Water Consumer Complaints: Indicators from Distribution System Sentinels, TG 284. http://chppm-www.apgea.army.mil/documents/TG/TECHGUID/TG284.pdf.

U.S. EPA. 2000. 40 CFR Part 141, Subpart Q. National Primary Drinking Water Regulations: Public Notification Rule; Final Rule. *Federal Register* (Part II). 65(87): 25982-26049. http://www.epa.gov/safewater/pws/pn/pnrule.pdf.

U.S. EPA. June 2000. Public Notification Handbook. EPA/816/R-00/010. Office of Water. Washington DC. http://www.epa.gov/safewater/pws/pn/handbook.pdf.

8 Appendices

8.1 Response Planning Matrix

Incident				Response	
Credibility	*Consequences*		*Other Considerations*	*Possible Actions*	*Anticipated Impacts on the public*
	# people affected	*Health Impact*			
Possible	10's	Minor			
		Moderate			
		Severe			
	100's	Minor			
		Moderate			
		Severe			
	1,000's	Minor			
		Moderate			
		Severe			
Credible	10's	Minor			
		Moderate			
		Severe			
	100's	Minor			
		Moderate			
		Severe			
	1,000's	Minor			
		Moderate			
		Severe			
Confirmed	10's	Minor			
		Moderate			
		Severe			
	100's	Minor			
		Moderate			
		Severe			
	1,000's	Minor			
		Moderate			
		Severe			

8.2 Threat Evaluation Worksheet

INSTRUCTIONS

The purpose of this worksheet is to help organize information about a contamination threat warning that would be used during the Threat Evaluation Process. The individual responsible for conducting the Threat Evaluation (e.g., the WUERM) should complete this worksheet. The worksheet is generic to accommodate information from different types of threat warnings; thus, there will likely be information that is unavailable or not immediately available. Other forms in the Appendices are provided to augment the information in this worksheet.

THREAT WARNING INFORMATION

Date/Time threat warning discovered: _____

Name of person who discovered threat warning: _____

Type of threat warning:

- ☐ Security breach
- ☐ Written threat
- ☐ News media
- ☐ Other _____
- ☐ Witness account
- ☐ Law enforcement
- ☐ Consumer complaints
- ☐ Phone threat
- ☐ Unusual water quality
- ☐ Public health notification

Identity of the contaminant: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

☐ Chemical ☐ Biological ☐ Radiological

Describe _____

_____

Time of contamination: ☐ Known ☐ Estimated ☐ Unknown

If known or estimated, provide additional detail below

Date and time of contamination: _____

Additional Information: _____

_____

Mode of contamination: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Site of contamination: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

Number of sites: _____

Provide the following information for each site.

Site #1

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Site #2

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Site #3

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

ADDITIONAL INFORMATION

Has there been a breach of security at the suspected site? ☐ Yes ☐ No
If "Yes", review the completed 'Security Incident Report' (Appendix 8.3)

Are there any witness accounts of the suspected incident? ☐ Yes ☐ No
If "Yes", review the completed 'Witness Account Report' (Appendix 8.4)

Was the threat made verbally over the phone? ☐ Yes ☐ No
If "Yes", review the completed 'Phone Threat Report' (Appendix 8.5)

Was a written threat received? ☐ Yes ☐ No
If "Yes", review the completed 'Written Threat Report' (Appendix 8.6)

Are there unusual water quality data or consumer complaints? ☐ Yes ☐ No
If "Yes", review the completed 'Water Quality/Consumer Complaint Report' (Appendix 8.7)

Are there unusual symptoms or disease in the population? ☐ Yes ☐ No
If "Yes", review the completed 'Public Health Report' (Appendix 8.8)

Is a 'Site Characterization Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Site Characterization Report' (Module 3, Appendix 8.3)

Are results of sample analysis available? ☐ Yes ☐ No
If "Yes", review the analytical results report, including appropriate QA/QC data

Is a 'Contaminant Identification Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Sample Analysis Report' (Module 5, Appendix 8.1)

Is there relevant information available from external sources? ☐ Yes ☐ No
Check all that apply

☐ Local law enforcement	☐ FBI	☐ DW primacy agency
☐ Public health agency	☐ Hospitals / 911 call centers	☐ US EPA / Water ISAC
☐ Media reports	☐ Homeland security alerts	☐ Neighboring utilities

☐ Other _____

Point of Contact: _____

_____

Summary of key information from external sources (provide detail in attachments as necessary):

_____

_____

_____

_____

_____

_____

THREAT EVALUATION

Has normal activity been investigated as the cause of the threat warning? ☐ Yes ☐ No

Normal activities to consider

- ☐ Utility staff inspections
- ☐ Construction or maintenance
- ☐ Operational changes
- ☐ Other _____
- ☐ Routine water quality sampling
- ☐ Contractor activity
- ☐ Water quality changes with a known cause

Is the threat 'possible'? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a 'possible' threat:

- ☐ None
- ☐ Increased monitoring/security
- ☐ Site characterization
- ☐ Other _____
- ☐ Isolation/containment

Is the threat 'credible'? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a 'credible' threat:

- ☐ Sample analysis
- ☐ Partial EOC activation
- ☐ Other _____
- ☐ Site characterization
- ☐ Public notification
- ☐ Isolation/containment
- ☐ Provide alternate water supply

Has a contamination incident been confirmed? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a confirmed incident:

- ☐ Sample analysis
- ☐ Full EOC activation
- ☐ Initiate remediation and recovery
- ☐ Other _____
- ☐ Site characterization
- ☐ Public notification
- ☐ Isolation/containment
- ☐ Provide alternate water supply

How do other organizations characterize the threat?

Organization	Evaluation	Comment
☐ Local Law Enforcement	☐ Possible ☐ Credible ☐ Confirmed	
☐ FBI	☐ Possible ☐ Credible ☐ Confirmed	
☐ Public Health Agency	☐ Possible ☐ Credible ☐ Confirmed	
☐ Drinking Water Primacy Agency	☐ Possible ☐ Credible ☐ Confirmed	
☐ Other	☐ Possible ☐ Credible ☐ Confirmed	
☐ Other	☐ Possible ☐ Credible ☐ Confirmed	

SIGNOFF

Name of person responsible for threat evaluation:

Print name _____

Signature _____ Date/Time: _____

8.3 Security Incident Report Form

INSTRUCTIONS

The purpose of this form is to help organize information about a security incident, typically a security breach, which may be related to a water contamination threat. The individual who discovered the security incident, such as a security supervisor, the WUERM, or another designated individual may complete this form. This form is intended to summarize information about a security breach that may be relevant to the threat evaluation process. This form should be completed for each location where a security incident was discovered.

DISCOVERY OF SECURITY INCIDENT

Date/Time security incident discovered: _____

Name of person who discovered security incident: _____

Mode of discovery:

- ☐ Alarm (building)
- ☐ Alarm (gate/fence)
- ☐ Alarm (access hatch)
- ☐ Video surveillance
- ☐ Utility staff discovery
- ☐ Citizen discovery
- ☐ Suspect confession
- ☐ Law enforcement discovery
- ☐ Other _____

Did anyone observe the security incident as it occurred? ☐ Yes ☐ No

If "Yes", complete the 'Witness Account Report' (Appendix 8.4)

SITE DESCRIPTION

Site Name: _____

Type of facility

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank
- ☐ Elevated storage tank
- ☐ Finished water reservoir
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

BACKGROUND INFORMATION

Have the following "normal activities" been investigated as potential causes of the security incident?

- ☐ Alarms with known and harmless causes
- ☐ Utility staff inspections
- ☐ Routine water quality sampling
- ☐ Construction or maintenance
- ☐ Contractor activity
- ☐ Other _____

Was this site recently visited *prior* to the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of previous visit: _____

Name of individual who visited the site: _____

Additional Information: _____
_____

Has *this location* been the site of previous security incidents? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of most recent security incident: _____

Description of incident: _____
_____
_____

What were the results of the threat evaluation for this incident?
☐ 'Possible' ☐ 'Credible' ☐ 'Confirmed'

Have security incidents occurred at *other locations* recently? ☐ Yes ☐ No
If "Yes", complete additional 'Security Incident Reports' (Appendix 8.3) for each site

Name of 1st additional site: _____
Name of 2nd additional site: _____
Name of 3rd additional site: _____

SECURITY INCIDENT DETAILS

Was there an alarm(s) associated with the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Are there sequential alarms (e.g., alarm on a gate and a hatch)? ☐ Yes ☐ No

Date and time of alarm(s): _____

Describe alarm(s): _____
_____

Is video surveillance available from the site of the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of video surveillance: _____

Describe surveillance: _____
_____
_____
_____

Unusual equipment found at the site and time of discovery of the security incident:

- ☐ Discarded PPE (e.g., gloves, masks)
- ☐ Tools (e.g., wrenches, bolt cutters)
- ☐ Lab equipment (e.g., beakers, tubing)
- ☐ None
- ☐ Empty containers (e.g., bottles, drums)
- ☐ Hardware (e.g., valves, pipe)
- ☐ Pumps or hoses
- ☐ Other _____

Describe equipment: _____

Unusual vehicles found at the site and time of discovery of the security incident:

- ☐ Car/sedan
- ☐ Flatbed truck
- ☐ SUV
- ☐ Construction vehicle
- ☐ Pickup truck
- ☐ None
- ☐ Other _____

Describe vehicles (including make/model/year/color, license plate #, and logos or markings): ____

Signs of tampering at the site and time of discovery of the security incident:

- ☐ Cut locks/fences
- ☐ Open/damaged access hatches
- ☐ Facility in disarray
- ☐ Open/damaged gates, doors, or windows
- ☐ Missing/damaged equipment
- ☐ None
- ☐ Other _____

Are there signs of sequential intrusion (e.g., locks removed from a gate and hatch)? ☐ Yes ☐ No

Describe signs of tampering: _____

Signs of hazard at the site and time of discovery of the security incident:

- ☐ Unexplained or unusual odors
- ☐ Unexplained dead or stressed vegetation
- ☐ Unexplained clouds or vapors
- ☐ Unexplained dead animals
- ☐ Unexplained liquids
- ☐ None
- ☐ Other _____

Describe signs of hazard: _____

SIGNOFF

Name of person responsible for documenting the security incident:

Print name _____

Signature _____ Date/Time: _____

8.4 Witness Account Report Form

INSTRUCTIONS

The purpose of this form is to document the observations of a witness to activities that might be considered an incident warning. The individual interviewing the witness, or potentially the witness, should complete this form. This may be the WUERM or an individual designated by incident command to perform the interview. If law enforcement is conducting the interview (which may often be the case), then this form may serve as a prompt for "utility relevant information" that should be pursued during the interview. This form is intended to consolidate the details of the witness account that may be relevant to the threat evaluation process. This form should be completed for each witness that is interviewed.

BASIC INFORMATION

Date/Time of interview: _____

Name of person interviewing the witness: _____

Witness contact information

Full Name: _____

Address: _____

Day-time phone: _____

Evening phone: _____

E-mail address: _____

Reason the witness was in the vicinity of the suspicious activity: _____

_____

_____

WITNESS ACCOUNT

Date/Time of activity: _____

Location of activity:

Site Name: _____

Type of facility

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank
- ☐ Elevated storage tank
- ☐ Finished water reservoir
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Type of activity

☐ Trespassing ☐ Vandalism ☐ Breaking and entering
☐ Theft ☐ Tampering ☐ Surveillance
☐ Other _____

Additional description of the activity _____
_____
_____
_____
_____

Description of suspects

Were suspects present at the site? ☐ Yes ☐ No

How many suspects were present? _____

Describe each suspect's appearance:

Suspect #	Sex	Race	Hair color	Clothing	Voice
1					
2					
3					
4					
5					
6					

Where any of the suspects wearing uniforms? ☐ Yes ☐ No
If "Yes," describe the uniform(s): _____
_____

Describe any other unusual characteristics of the suspects: _____
_____
_____
_____
_____

Did any of the suspects notice the witness? ☐ Yes ☐ No
If "Yes," how did they respond: _____
_____

Vehicles at the site

Were vehicles present at the site? ☐ Yes ☐ No

Did the vehicles appear to belong to the suspects? ☐ Yes ☐ No

How many vehicles were present? _____

Describe each vehicle:

Vehicle #	Type	Color	Make	Model	License plate
1					
2					
3					
4					
5					
6					

Where there any logos or distinguishing markings on the vehicles? ☐ Yes ☐ No
If "Yes," describe: _____

Provide any additional detail about the vehicles and how they were used (if at all): _____

Equipment at the site

Was any unusual equipment present at the site? ☐ Yes ☐ No

☐ Explosive or incendiary devices
☐ PPE (e.g., gloves, masks)
☐ Tools (e.g., wrenches, bolt cutters)
☐ Lab equipment (e.g., beakers, tubing)
☐ Firearms
☐ Containers (e.g., bottles, drums)
☐ Hardware (e.g., valves, pipe, hoses)
☐ Pumps and related equipment
☐ Other _____

Describe the equipment and how it was being used by the suspects (if at all): _____

Unusual conditions at the site

Were there any unusual conditions at the site? ☐ Yes ☐ No

☐ Explosions or fires
☐ Dead/stressed vegetation
☐ Fogs or vapors
☐ Dead animals
☐ Unusual odors
☐ Unusual noises
☐ Other _____

Describe the site conditions: _____

Additional observations

Describe any additional details from the witness account: _____

_____

_____

_____

_____

_____

SIGNOFF

Name of interviewer:

Print name _____

Signature _____ Date/Time: _____

Name of witness:

Print name _____

Signature _____ Date/Time: _____

8.5 Phone Threat Report Form

INSTRUCTIONS

This form is intended to be used by utility staff that regularly answer phone calls from the public (e.g., call center operators). The purpose of this form is to help these staff capturer as much information from a threatening phone call while the caller is on the line. It is important that the operator keep the caller on the line as long as possible in order to collect additional information. Since this form will be used during the call, it is important that operators become familiar with the content of the form. The sections of the form are organized with the information that should be collected during the call at the front of the form (i.e., Basic Call Information and Details of Threat) and information that can be completed immediately following the call at the end of the form (i.e., the description of the caller). The information collected on this form will be critical to the threat evaluation process.

Remember, tampering with a drinking water system is a crime under the SDWA Amendments!

THREAT NOTIFICATION

Name of person receiving the call: _____

Date phone call received: _____ **Time phone call received:** _____

Time phone call ended: _____ **Duration of phone call:** _____

Originating number: _____ **Originating name:** _____

*If the number/name is not displayed on the caller ID, press *57 (or call trace) at the end of the call and inform law enforcement that the phone company may have trace information.*

Is the connection clear? ☐ Yes ☐ No

Could call be from a wireless phone? ☐ Yes ☐ No

DETAILS OF THREAT

Has the water already been contaminated? ☐ Yes ☐ No

Date and time of contaminant introduction known? ☐ Yes ☐ No

Date and time if known: _____

Location of contaminant introduction known? ☐ Yes ☐ No

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Name or type of contaminant known? ☐ Yes ☐ No

Type of contaminant

☐ Chemical ☐ Biological ☐ Radiological

Specific contaminant name/description: _____

_____

Mode of contaminant introduction known? ☐ Yes ☐ No

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Motive for contamination known? ☐ Yes ☐ No

☐ Retaliation/revenge ☐ Political cause ☐ Religious doctrine

☐ Other _____

Describe motivation: _____

_____

CALLER INFORMATION

Basic Information:

Stated name: _____

Affiliation: _____

Phone number: _____

Location/address: _____

Caller's Voice:

Did the voice sound disguised or altered? ☐ Yes ☐ No

Did the call sound like a recording? ☐ Yes ☐ No

Did the voice sound? ☐ Male / ☐ Female ☐ Young / ☐ Old

Did the voice sound familiar? ☐ Yes ☐ No

If 'Yes,' who did it sound like? _____

Did the caller have an accent? ☐ Yes ☐ No

If 'Yes,' what nationality? _____

How did the caller sound or speak?

☐ Educated ☐ Well spoken ☐ Illiterate

☐ Irrational ☐ Obscene ☐ Incoherent

☐ Reading a script ☐ Other _____

What was the caller's tone of voice?

☐ Calm	☐ Angry	☐ Lisping	☐ Stuttering/broken
☐ Excited	☐ Nervous	☐ Sincere	☐ Insincere
☐ Slow	☐ Rapid	☐ Normal	☐ Slurred
☐ Soft	☐ Loud	☐ Nasal	☐ Clearing throat
☐ Laughing	☐ Crying	☐ Clear	☐ Deep breathing
☐ Deep	☐ High	☐ Raspy	☐ Cracking

☐ Other _____

Were there background noises coming from the caller's end?

☐ Silence		
☐ Voices	describe	_____
☐ Children	describe	_____
☐ Animals	describe	_____
☐ Factory sounds	describe	_____
☐ Office sounds	describe	_____
☐ Music	describe	_____
☐ Traffic/street sounds	describe	_____
☐ Airplanes	describe	_____
☐ Trains	describe	_____
☐ Ships or large boats	describe	_____

☐ Other: _____

SIGNOFF

Name of call recipient:

Print name _____

Signature _____ Date/Time: _____

Name of person completing form (if different from call recipient):

Print name _____

Signature _____ Date/Time: _____

8.6 Written Threat Report Form

INSTRUCTIONS

The purpose of this form is to summarize significant information from a written threat received by a drinking water utility. This form should be completed by the WUERM or an individual designated by incident command to evaluate the written threat. The summary information provided in this form is intended to support the threat evaluation process; however, the completed form is not a substitute for the complete written threat, which may contain additional, significant details.

The written threat itself (e.g., the note, letter, e-mail message, etc.) may be considered evidence and thus should be minimally handled (or not handled at all) and placed into a clean plastic bag to preserve any forensic evidence.

Remember, tampering with a drinking water system is a crime under the SDWA Amendments!

SAFETY

A suspicious letter or package could pose a threat in and of itself, so caution should be exercised if such packages are received. The US Postal Service has issued guidance when dealing with suspicious packages (http://www.usps.com/news/2001/press/pr01_1022gsa.htm).

THREAT NOTIFICATION

Name of person receiving the written threat: _____

Person(s) to whom threat was addressed: _____

Date threat received: _____ **Time threat received:** _____

How was the written threat received?

☐ US Postal service ☐ Delivery service ☐ Courier
☐ Fax ☐ E-mail ☐ Hand delivered
☐ Other _____

If mailed, is the return address listed? ☐ Yes ☐ No

_____

_____

If mailed, what is the date and location of the postmark? _____

_____

If delivered, what was the service used (list any tracking numbers)? _____

_____

If Faxed, what is the number of the sending fax? _____

If E-mailed, what is the e-mail address of sender? _____

_____

If hand-delivered, who delivered the message? _____

_____

DETAILS OF THREAT

Has the water already been contaminated? ☐ Yes ☐ No

Date and time of contaminant introduction known? ☐ Yes ☐ No

Date and time if known: _____

Location of contaminant introduction known? ☐ Yes ☐ No

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Name or type of contaminant known? ☐ Yes ☐ No

Type of contaminant

☐ Chemical ☐ Biological ☐ Radiological

Specific contaminant name/description: _____

_____

Mode of contaminant introduction known? ☐ Yes ☐ No

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Motive for contamination known? ☐ Yes ☐ No

☐ Retaliation/revenge ☐ Political cause ☐ Religious doctrine
☐ Other _____

Describe motivation: _____

_____

NOTE CHARACTERISITCS

Perpetrator Information:

Stated name: _____
Affiliation: _____
Phone number: _____
Location/address: _____

Condition of paper/envelop:

- ☐ Marked personal
- ☐ Marked confidential
- ☐ Properly addressed
- ☐ Neatly typed or written
- ☐ Clean
- ☐ Corrected or marked-up
- ☐ Crumpled or wadded up
- ☐ Soiled/stained
- ☐ Torn/tattered
- ☐ Other: _____

How was the note prepared?

- ☐ Handwritten in print
- ☐ Handwritten in script
- ☐ Computer typed
- ☐ Machine typed
- ☐ Spliced (e.g., from other typed material)
- ☐ Other: _____

If handwritten, does writing look familiar? ☐ Yes ☐ No

_____

Language:

- ☐ Clear English
- ☐ Poor English
- ☐ Another language: _____
- ☐ Mixed languages: _____

Writing Style

- ☐ Educated
- ☐ Proper grammar
- ☐ Logical
- ☐ Uneducated
- ☐ Poor grammar/spelling
- ☐ Incoherent
- ☐ Use of slang
- ☐ Obscene
- ☐ Other: _____

Writing Tone

- ☐ Clear
- ☐ Direct
- ☐ Sincere
- ☐ Condescending
- ☐ Accusatory
- ☐ Angry
- ☐ Agitated
- ☐ Nervous
- ☐ Irrational
- ☐ Other: _____

SIGNOFF

Name of individual who received the threat:

Print name _____

Signature _____ Date/Time: _____

Name of person completing form (if different from written threat recipient):

Print name _____

Signature _____ Date/Time: _____

8.7 Water Quality/Consumer Complaint Report Form

INSTRUCTIONS
This form is provided to guide the individual responsible for evaluating unusual water quality data or consumer complaints. It is designed to prompt the analyst to consider various factors or information when evaluating the unusual data. The actual data used in this analysis should be compiled separately and appended to this form. The form can be used to support the threat evaluation due to a threat warning from unusual water quality or consumer complaints, or another type of threat warning in which water quality data or consumer complaints are used to support the evaluation.

Note that in this form, water quality refers to both specific water quality parameters and the general aesthetic characteristics of the water that might result in consumer complaints.

Threat warning is based on: ☐ Water quality ☐ Consumer complaints ☐ Other

What is the water quality parameter or complaint under consideration?

Are unusual consumer complaints corroborated by unusual water quality data?

Is the unusual water quality indicative of a particular contaminant of concern? For example, is the color, order, or taste associated with a particular contaminant?

Are consumers in the affected area experiencing any unusual health symptoms?

What is 'typical' for consumer complaints for the current season and water quality?
Number of complaints.
Nature of complaints.
Clustering of complaints

What is considered to be 'normal' water quality (i.e., what is the baseline water quality data or level of consumer complaints)?

What is reliability of the method or instrumentation used for the water quality analysis?
Are standards and reagents OK?
Is the method/instrument functioning properly?

Based on recent data, does the unusual water quality appear to be part of a gradual trend (i.e., occurring over several days or longer)?

Are the unusual water quality observations sporadic over a wide area, or are they clustered in a particular area?
What is the extent of the area? A pressure zone. A neighborhood. A city block. A street. A building.

If the unusual condition isolated to a specific area:

Is this area being supplied by a particular plant or source water?
Have there been any operational changes at the plant or in the affected area of the system?
Has there been any flushing or distribution system maintenance in the affected area?
Has there been any repair or construction in the area that could impact water quality?

SIGNOFF

Name of person completing form:

Print name _____

Signature _____ Date/Time: _____

8.8 Public Health Information Report Form

INSTRUCTIONS

The purpose of this form is to summarize significant information about a public health episode that could be linked to contaminated water. This form should be completed by the WUERM or an individual designated by incident command. The information compiled in this form is intended to support the threat evaluation process.

In the case of a threat warning due to a report from public health, it is likely that the public health agency will assume incident command during the investigation. The drinking water utility will likely play a support role during the investigation, specifically to help determine whether or not water might be the cause.

PUBLIC HEALTH NOTIFICATION

Date and Time of notification: _____ _____

Name of person who received the notification: _____

Contact information for individual providing the notification

Full Name: _____
Title: _____
Organization: _____
Address: _____
Day-time phone: _____
Evening phone: _____
Fax Number: _____
E-mail address: _____

Why is this person contacting the drinking water utility? _____
_____
_____

Has the state or local public health agency been notified? ☐ Yes ☐ No

If "No," the appropriate public health official should be immediately notified.

DESCRIPTION OF PUBLIC HEALTH EPISODE

Nature of public health episode:

☐ Unusual disease (mild) ☐ Unusual disease (severe) ☐ Death
☐ Other: _____

Symptoms:

☐ Diarrhea ☐ Vomiting/nausea ☐ Flu-like symptoms
☐ Fever ☐ Headache ☐ Breathing difficulty
☐ Other: _____

Describe symptoms: _____
_____

Causative Agent: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

☐ Chemical ☐ Biological ☐ Radiological

Describe _____

_____

Estimate of time between exposure and onset of symptoms: _____

Exposed Individuals:

Location where exposure is thought to have occurred

☐ Residence ☐ Work ☐ School
☐ Restaurant ☐ Shopping mall ☐ Social gathering
☐ Other: _____

Additional notes on location of exposure: _____
_____

Collect addresses for specific locations where exposure is thought to have occurred.

Is the pattern of exposure clustered in a specific area? ☐ Yes ☐ No

Extent of area

☐ Single building ☐ Complex (several buildings) ☐ City block
☐ Neighborhood ☐ Cluster of neighborhoods ☐ Large section of city
☐ Other: _____

Additional notes on extent of area: _____
_____

Do the exposed individuals represent a disproportionate number of:

☐ Immune compromised ☐ Elderly ☐ Children
☐ Infants ☐ Pregnant women ☐ Women
☐ Other: _____
☐ None, no specific groups dominate the makeup of exposed individuals

EVALUATION OF LINK TO WATER

Are the symptoms consistent with typical waterborne diseases, such as gastrointestinal disease, vomiting, or diarrhea? ☐ Yes ☐ No

Does the area of exposure coincide with a specific area of the system, such as a pressure zone or area feed by a specific plant? ☐ Yes ☐ No

Were there any consumer complaints within the affected area? ☐ Yes ☐ No

Were there any unusual water quality data within the affected area? ☐ Yes ☐ No

Were there any process upsets or operational changes? ☐ Yes ☐ No

Was there any construction/maintenance within the affected area? ☐ Yes ☐ No

Were there any security incidents within the affected area? ☐ Yes ☐ No

---

SIGNOFF

Name of person completing form:

Print name _____

Signature _____ Date/Time: _____

8.9 Overview of the "Water Contaminant Information Tool"

What is the WCIT? Fundamentally, the Water Contaminant Information Tool (WCIT) is a compilation of information on nontraditional water contaminants. Nontraditional contaminants are those that are not significant from a regulatory or operational perspective, but which could have substantial adverse consequences to the public and/or utility if accidentally or intentionally introduced into the drinking water. The WCIT contains peer-reviewed information about these nontraditional contaminants that is relevant to the drinking water treatment industry. This information is managed in a relational database that will allow a user to search and sort contaminant information based on key properties. It will also allow users to create summary reports for each contaminant.

What is the purpose of the WCIT? This tool is being developed to support the drinking water treatment industry in the management of water contamination threats and incidents. It will provide relevant, accurate information to users for a variety of non-traditional drinking water contaminants. This information will be relevant to planning for and responding to drinking water contamination threats and incidents. As a planning tool, the WCIT can be used to support vulnerability assessments, emergency response plans, and the development of site-specific response guidelines. As a response tool, the WCIT can provide information about specific water contaminants, which will be necessary to make appropriate response decisions. (The WCIT will likely be **most** useful as a response tool.)

What type of information will be contained in the WCIT? The nontraditional contaminants in the WCIT will include pathogens, chemicals, and radionuclides that are of concern to drinking water. For each contaminant, the following type of information will be included in the WCIT, when available:

- Contaminant properties, such as solubility, volatility, and thermal stability.
- Fate and transport information that indicates the persistence of the contaminant in water.
- Toxicity data for chemicals and infectivity data for pathogens.
- Signs and symptoms of exposure to the contaminant.
- Efficacy of treatment processes for removing or neutralizing the contaminant.
- Methods to detect the contaminant.
- Impact of the contaminant on environmental indicators.

What is the Status of the WCIT? The WCIT is currently under development. A system prototype has been designed, constructed and populated with an initial set of data for testing. The results of system testing will be used to refine the design and functionality of the system. Next, the system will be fully populated with information for priority contaminants. It is anticipated that an initial version of the WCIT will be made available in late 2004.

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-002
www.epa.gov/safewater/security
December 2003

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

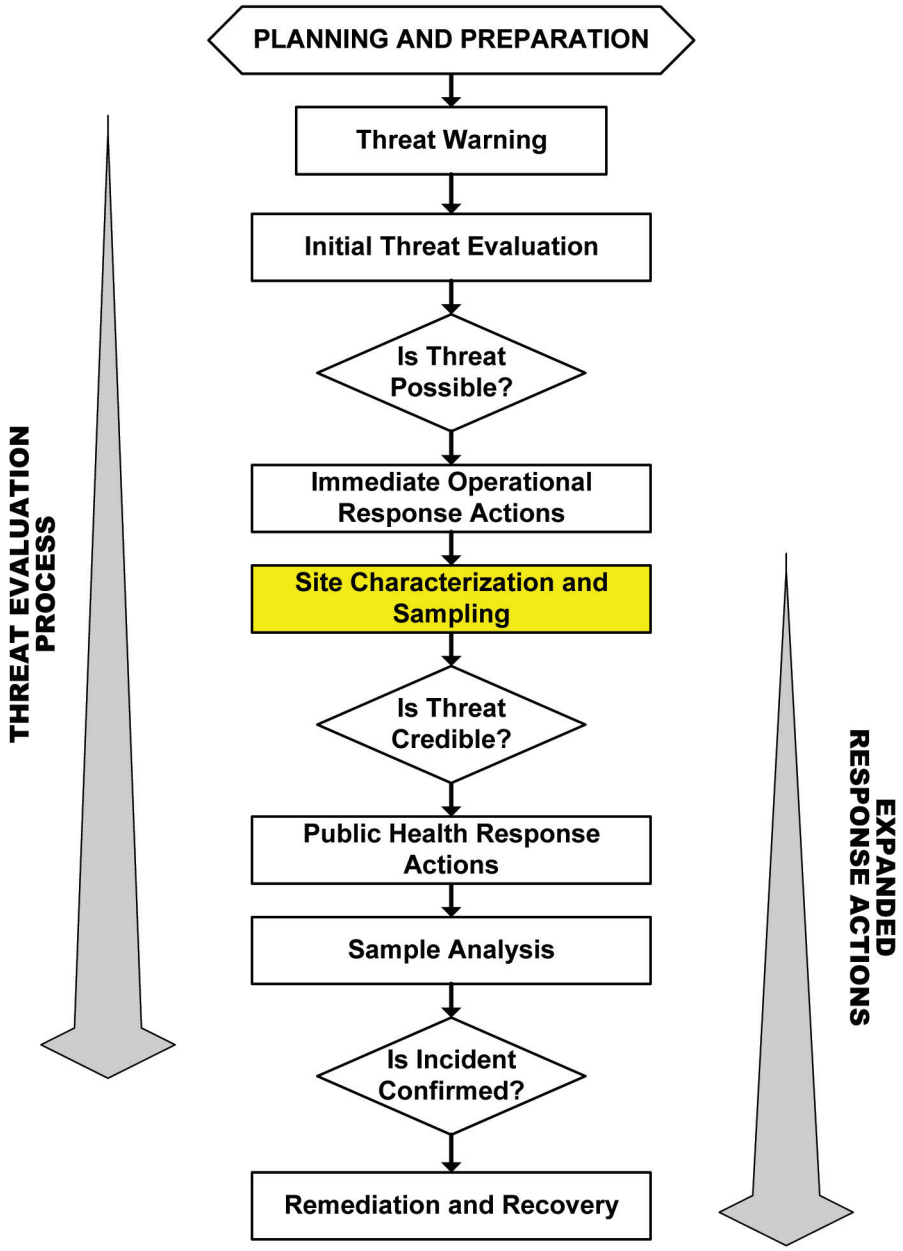
Interim Final - December 2003

Module 3:
Site Characterization and Sampling Guide

Response Protocol Toolbox:
Planning for and Responding to Drinking Water Contamination Threats and Incidents

Module 3: Site Characterization and Sampling Guide

Interm Final - December 2003



OTHER RESPONSE PROTOCOL TOOLBOX MODULES

Module 1: Water Utility Planning Guide *(December 2003)*
Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to prepare for response to contamination threats and incidents.

Module 2: Contamination Threat Management Guide *(December 2003)*
Module 2 presents the overarching framework for management of contamination threats to the drinking water supply. The threat management process involves two parallel and interrelated activities: 1) evaluating the threat, and 2) making decisions regarding appropriate actions to take in response to the threat.

Module 3: Site Characterization and Sampling Guide *(December 2003)*
Module 3 describes the site characterization process in which information is gathered from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Module 4: Analytical Guide *(December 2003)*
Module 4 presents an approach to the analysis of samples collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples that may contain an unknown contaminant. The framework is flexible and will allow the approach to be crafted based on the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Module 5: Public Health Response Guide *(available March 2004)*
Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interaction among the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Module 6: Remediation and Recovery Guide *(available March 2004)*
Module 6 describes the planning and implementation of remediation and recovery activities that would be necessary following a confirmed contamination incident. The remediation process involves a sequence of activities, including: system characterization; selection of remedy options; provision of an alternate drinking water supply during remediation activities; and monitoring to demonstrate that the system has been remediated. Module 6 describes the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

TABLE OF CONTENTS

1 INTRODUCTION 11

2 OVERVIEW OF SITE CHARACTERIZATION PROCESS 13

2.1 PROCESS OVERVIEW 13
2.2 ROLES AND RESPONSIBILITIES 16

3 PLANNING FOR SITE CHARACTERIZATION 18

3.1 SAFETY AND PERSONNEL PROTECTION 18
3.2 SAMPLE COLLECTION KITS AND FIELD TEST KITS 20
3.2.1 SAMPLE COLLECTION KITS 20
3.2.2 FIELD TEST KITS 27
3.3 GENERIC SITE CHARACTERIZATION PLAN 30
3.4 EVALUATION OF BASELINE WATER QUALITY INFORMATION 31
3.4.1 GENERAL WATER QUALITY PARAMETERS 31
3.4.2 BACKGROUND LEVELS OF SPECIFIC CONTAMINANTS 32
3.5 QUALITY ASSURANCE FOR FIELD TESTING AND SAMPLING 34
3.6 MAINTAINING CRIME SCENE INTEGRITY 34

4 SITE CHARACTERIZATION PROTOCOL 36

4.1 CUSTOMIZING THE SITE CHARACTERIZATION PLAN 36
4.1.1 INITIAL EVALUATION 36
4.1.2 IDENTIFICATION OF INVESTIGATION SITE 37
4.1.3 SITE HAZARD ASSESSMENT 39
4.1.4 SAMPLING APPROACH 41
4.1.5 FORMATION OF A SITE CHARACTERIZATION TEAM 44
4.1.6 EXAMPLES OF SITE CHARACTERIZATION PLAN CUSTOMIZATION 45
4.2 APPROACHING THE SITE 50
4.2.1 ESTABLISH SITE ZONES 50
4.2.2 FIELD SAFETY SCREENING 50
4.2.3 INITIAL OBSERVATION OF SITE CONDITIONS 50
4.3 CHARACTERIZING THE SITE 52
4.3.1 EVALUATION OF SITE CONDITIONS 53
4.3.2 RAPID FIELD TESTING 53
4.4 COLLECTING SAMPLES 54
4.4.1 GENERAL SAMPLING PROCEDURES 54
4.4.2 CHEMICAL SAMPLING PROCEDURES 56
4.4.3 MICROBIOLOGICAL SAMPLING PROCEDURES 57
4.5 EXITING THE SITE 60

5 SITE CHARACTERIZATION REPORT 62

6 SAMPLE PACKAGING AND TRANSPORT 64

6.1 LOW HAZARD SAMPLES 65
6.1.1 PACKAGING 65
6.1.2 TRANSPORT 65
6.2 HIGH HAZARD SAMPLES 66
6.2.1 PACKING 66
6.2.2 TRANSPORT 68

7 REFERENCES AND RESOURCES 69

8 APPENDICES 71

8.1 SITE CHARACTERIZATION PLAN TEMPLATE 71
8.2 SITE CHARACTERIZATION REPORT FORM 75
8.3 FIELD TESTING RESULTS FORM 81
8.4 SAMPLE DOCUMENTATION FORM 82
8.5 CHAIN OF CUSTODY FORM 83

LIST OF TABLES

TABLE 3-1: EXAMPLE DESIGN OF AN EMERGENCY WATER SAMPLE COLLECTION KIT 21
TABLE 3-2: SAMPLES OF CONTAINERS FOR EMERGENCY WATER SAMPLE COLLECTION KIT 22
TABLE 3-3: CORE AND EXPANDED FIELD TEST KITS 28
TABLE 3-4: CHARACTERISTICS OF EXAMPLE CHEMICAL CONTAMINANTS 52

LIST OF FIGURES

FIGURE 3-1: OVERVIEW OF THE SITE CHARACTERIZATION PROCESS 14
FIGURE 3-2: INTEGRATION OF SITE HAZARD ASSESSMENT INTO SITE CHARACTERIZATION PROCESS 40
FIGURE 3-3: INTEGRATION OF SITE HAZARD ASSESSMENT INTO THE SAMPLING APPROACH 43
FIGURE 3-4: SAMPLING APPROACH FOR MICROBIAL CONTAMINANTS 57
FIGURE 3-5: ULTRAFILTRATION FIELD CONCENTRATION APPARATUS 59

ACRONYMS

AWWARF	American Water Works Association Research Foundation
CDC	Centers for Disease Control and Prevention
CHRIS	Chemical Hazards Response Information System
ERP	Emergency response plan
ETV	Environmental Technology Verification
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FRP	Federal Response Plan
HazMat	Hazardous materials
HDPE	High density polyethylene
ISAC	Information Sharing and Analysis Center
LRN	Laboratory Response Network
MWCO	Molecular weight cut-off
OSC	On scene coordinator
PPE	Personal protective equipment
psi	Pounds per square inch
QA	Quality assurance
QC	Quality control
SCADA	Supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SVOC	Semi-volatile organic chemical
TOC	Total organic carbon
URL	Uniform resource locator
US EPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
UV	Ultraviolet
VOC	Volatile organic chemical
WCIT	Water contaminant information tool
WUERM	Water utility emergency response manager

GLOSSARY

Definitions in this glossary are specific to the Response Protocol Tool Box but conform to common usage as much as possible.

Analytical Approach – a plan describing the specific analyses that are performed on the samples collected in the event of a water contamination threat. The analytical approach is based on the specific information available about a contamination threat.

Analytically Confirmed – in the context of the *analytical approach*, a contaminant is considered to be analytically confirmed if it has undergone analytical confirmation, as defined herein.

Analytical Confirmation – the process of determining an analyte in a defensible manner.

Causative Agent – the pathogen, chemical, or other substance that is the cause of disease or death in an individual.

Composite Sample – a sample composed of several specific aliquot collected at various sample locations and/or different points in time, which are then combined to form one composite sample.

'Confirmed' – in the context of the *threat evaluation* process, a water contamination incident is 'confirmed' if the information collected over the course of the threat evaluation provides definitive evidence that the water has been contaminated.

Contamination Site – the location where a contaminant is known or suspected to have been introduced into a drinking water system. For example, a distribution system storage tank where a security breach has occurred may be designated as a suspected contamination site. The contamination site will likely be designated as an *investigation site* for the purpose of *site characterization*.

Core Field Testing – analysis performed at the investigation site for radiation, cyanide, residual chlorine, and pH. Core field testing is performed as part of *site characterization* and is composed of two elements, *field safety screen* and *rapid field testing*.

'Credible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'credible' if information collected during the threat evaluation process corroborates information from the *threat warning*.

Drinking Water Primacy Agency – the *agency* that has primary enforcement responsibility for national drinking water regulations, namely the Safe Drinking Water Act as amended. Drinking water primacy for a particular state may reside in one of a variety of agencies, such as health departments, environmental quality departments, etc. The drinking water primacy agency is typically the State Health Agency or the State Environmental Agency. The drinking water

primacy agency may also play the role of *technical assistance provider* to drinking water utilities.

Emergency Operations Center – a pre-designated facility established by an agency or jurisdiction to coordinate the overall agency or jurisdictional response and support to an emergency.

Emergency Response Plan – a document that describes the actions that a drinking water utility would take in response to various emergencies, disasters, and other unexpected incidents.

Expanded Field Testing – analysis of water at the site of a suspected contamination incident for parameters beyond those covered under core field testing (e.g., VOCs, chemical weapons, biotoxins, etc).

Field Safety Screening – screening performed to detect any environmental hazards (e.g., in the air or on surfaces) that might pose a threat to the *site characterization* team. Monitoring for radioactivity as the team approaches the site is an example of field safety screening.

Field Sample Concentrate – the term used for the retentate from the ultrafiltration device used for sampling/concentration of unknown microbial contaminants.

Filtrate – in ultrafiltration, the water that passes through the membrane and which contains no particles smaller than the molecular weight cutoff of the membrane.

Grab Sample - a single sample collected at a particular time and place that represents the composition of the water, air, or soil only at that time and location.

Hazard Assessment – the process of evaluating available information about the site for identify potential hazards that might pose a risk to the site characterization team. The hazard assessment results in assigning one of four levels to risk: low hazard, radiological hazard, high chemical hazard, or high biological hazard.

Immediate Operational Response – an action taken in response to a 'possible' contamination threat in an attempt to minimize the potential for exposure to the potentially contaminated water. Immediate operational response actions will generally have a negligible impact on consumers.

Incident Commander – the individual responsible for the management of all incident operations.

Investigation Site – the location where site characterization activities are performed. If a suspected *contamination site* has been identified, it will likely be designated as a primary investigation site. Additional or secondary investigation sites may also be identified due to the potential spread of a contaminant.

Pathogen - an infectious microbial organism that is capable of causing disease.

Personal protective equipment (PPE) – equipment and supplies designed to protect employees from serious injuries or diseasees resulting from contact with chemical, radiological, biological, or other hazards. PPE includes face shields, safety glasses, goggles, laboratory coats, gloves, and respirators.

'Possible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'possible' if the circumstances of the *threat warning* appear to have provided an opportunity for contamination.

Protective Action Zone – at the site of a hazardous materials incident, this is the zone that is potentially dangerous to life and health, and specialized *PPE* is required to enter and perform work in this zone. This zone may also be referred to as the exclusion zone.

Quality Assurance – an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Control – the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the client; operational techniques and activities that are used to fulfill requirements for quality.

Rapid Field Testing – analysis of water during *site characterization* using rapid field water testing technology in an attempt to tentatively identify contaminants or unusual water quality.

Response Guidelines – a manual designed to be used **during** the response to a water contamination threat. Response Guidelines should be easy to use and contain forms, flow charts, and simple instructions to support staff in the field or decision officials in the *Emergency Operations Center* during management of a crisis.

Retentate - in ultrafiltration, the retentate is the solution that contains the particles that do not pass through the membrane filter. The retentate is also called the concentrate.

Secure Area – a locked space, such as a cabinet or vault, with access restricted to authorized personnel.

Site Characterization – the process of collecting information from an *investigation site* in order to support the evaluation of a drinking water contamination threat. Site characterization activities include the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection.

Site Characterization Plan – a brief document that summarizes the activities that will occur during the characterization of an *investigation site*. The plan may be generic in that it covers the general scope of activities, or customized to describe the activities that will occur at a specific investigation site in response to a specific threat warning.

Site Characterization Team – the individual or group that is responsible for the implementation of all site characterization activities, including: the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection. A site characterization team benefits from expertise in the areas of water quality, security, and operations. Under hazardous conditions, individuals with expertise in responding to hazardous sites should be part of the team.

Site Characterization Team Leader – the individual or group that is responsible for the coordinating the site characterization activities in the field and ensuring that incident command remains informed as those activities progress.

Site Perimeter – the boundary of the protective action zone at the site of a suspected contamination incident.

Staging Area – location set up outside of the *protective action zone* at the site of a suspected contamination incident where resources can be placed while awaiting assignment and other operations such as personnel decontamination can be safely performed.

Technical Assistance Provider – any organization or individual that provides assistance to drinking water utilities in meeting their mission to provide an adequate and safe supply of water to their customers. The *drinking water primacy agency* may serve as a technical assistance provider.

Tentative Identification – the contaminant identity is hypothesized based on available information from the site characterization report. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; tentatively positive results for a specific contaminant during field safety screening or rapid field testing; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the disease-causing agent.

Threat – an indication that a harmful *incident*, such as contamination of the drinking water supply, may have occurred. The threat may be direct, such as a verbal or written threat, or circumstantial, such as a security breach or unusual water quality.

Threat Evaluation – part of the threat management process in which all available and relevant information about the threat is evaluated to determine if the threat is 'possible' or 'credible', or if a contamination *incident* has been 'confirmed.' This is an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

Threat Management – the process of evaluating a contamination threat and making decisions about appropriate response actions. The threat management process includes the parallel activities of the *threat evaluation* and making *response decisions*. The threat management process is considered in three stages: 'possible', 'credible', and 'confirmatory.' The severity of the threat and the magnitude of the response decisions escalate as a threat progresses through these stages.

Threat Warning – an unusual occurrence, observation, or discovery that indicates a potential contamination incident and initiates actions to address this concern.

Ultrafiltration – a filtration process for water that uses membranes to preferentially separate very small particles that are larger than the membrane's molecular weight cut-off, typically greater than 10,000 Daltons.

Water Contamination Incident – a situation in which a contaminant has been successfully introduced into the system. A water contamination incident may or may not be preceded by a water contamination threat.

Water Contamination Threat – a situation in which the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. Compare *water contamination threat* with *water contamination incident.* Note that tampering with a water system is a crime under the Safe Drinking Water Act as amended by the Bioterrorism Act.

Water Utility Emergency Response Manager (WUERM) – the individual(s) within the drinking water utility management structure that has the responsibility and authority for managing certain aspects of the utility's response to an emergency (e.g., a contamination threat) particularly during the initial stages of the response. The responsibilities and authority of the WUERM are defined by utility management and will likely vary based on the circumstances of a specific utility.

1 Introduction

Site characterization is defined as the process of collecting information from an investigation site in order to support the evaluation of a drinking water contamination threat. Site characterization activities include the site evaluation, *field safety screening*, *rapid field testing* of the water, and sample collection. The *investigation site* is the focus of site characterization activities, and if a suspected *contamination site* has been identified, it will likely be designated as the primary investigation site. Additional or secondary investigation sites may be identified due to the potential spread of a suspected contaminant. The results of site characterization are of critical importance to the *threat evaluation* process described in Module 2. Module 3 describes procedures and protocols for implementing site characterization activities, which should be adapted to a user's specific needs and objectives rather than interpreted as prescriptive guidelines.

There are two broad phases of site characterization: planning and implementation. The *incident commander* is responsible for planning, while the *site characterization team* is responsible for implementing the site characterization plan. This module is intended as a resource for those involved in either the planning or implementation phases of site characterization. While the target audience is primarily drinking water utility managers and staff, other organizations may be involved in site characterization activities. Thus, this module may be useful to first responders (e.g., police and fire departments), HazMat responders, law enforcement (e.g., FBI and EPA criminal investigators), Civil Support Teams, and environmental response teams from EPA or other government agencies.

This module, like the entirety of the "Response Protocol Toolbox," was developed as a planning tool. Individuals involved in planning or implementing site characterization activities are encouraged to review this module in its entirety, as well as the other modules in the "Response Protocol Toolbox," to obtain a more comprehensive understanding of the threat management process. The objectives of Module 3 are to:

- Describe planning and implementation of site characterization activities in response to a water contamination threat.
- Describe procedures for the site evaluation, field safety screening, rapid field testing, sample collection, and sample transport.

This module is organized into eight sections as described below.

Section 1: <u>Introduction</u>: Describes the objectives and overall organization of this module.

Section 2: <u>Overview of Site Characterization Process</u>: Summarizes the process of site characterization, including planning, conducting on-site activities, sample collection and sample shipping to a laboratory for analysis. Detailed information is presented in subsequent sections.

Section 3: Planning for Site Characterization: Describes planning and preparation necessary for the safe and effective implementation of site characterization activities.

Section 4: Site Characterization Protocol: Describes the activities performed under each of the five stages of site characterization: customizing the site characterization plan, approaching the site, characterizing the site, sample collection, and exiting the site.

Section 5: Site Characterization Report: Describes how information from site characterization activities can be documented in order to evaluate the credibility of a threat and make decisions regarding appropriate response actions.

Section 6: Sample Packing and Transport: Describes how samples should be packaged and transported to an analytical laboratory for analysis or archiving.

Section 7: References and Resources: Lists the references cited in this module and additional information resources.

Section 8: Appendices: Provides forms that support this module, which can be used to develop a utility's site-specific *Response Guidelines*.

2 Overview of Site Characterization Process

2.1 Process Overview

Figure 3-1 is a flow chart illustrating the site characterization process, and serves as a roadmap to the rest of the document. The site characterization process is considered in five stages:

1. Customizing the Site Characterization Plan. A site characterization plan is developed for a specific threat (possibly from a generic site characterization plan) and guides the team during site characterization activities (Section 4.1).
2. Approaching the Site. Before entering the site, an initial assessment of site conditions and potential hazards is conducted at the site perimeter (Section 4.2).
3. Characterizing the Site. The customized site characterization plan is implemented by conducting a detailed site investigation and rapid testing of the water (Section 4.3).
4. Collecting Samples. Water samples are collected in the event that laboratory analysis is required (Section 4.4).
5. Exiting the Site. Following completion of site characterization, the site is secured and personnel exit the site and undergo any necessary decontamination (Section 4.5).

These five stages are shown in the center of Figure 3-1. Various activities that may be performed during each of these stages are shown on the right side of the figure.

While site characterization can be considered and implemented as a discrete process, it is important to regard it as an element of the threat evaluation process, as discussed in Module 2. In particular, site characterization is an activity initiated in response to a *'possible'* contamination threat in order to gather information to help determine whether or not the threat is *'credible.'* This is graphically depicted in Figure 3-1 in which the threat evaluation process is represented the large arrow on the left with linkages to the site characterization process at key points. Initially, information from the threat evaluation supports the development of the customized *site characterization plan*. As this plan is implemented, the observations and results from site characterization feed into the threat evaluation. In turn, the revised threat evaluation may indicate that the threat is 'credible,' 'not credible,' or that the site characterization plan needs to be revised in the field to collect more information in order to make this determination. Because threat evaluation and site characterization are interdependent, the incident commander must be in constant communication with the site characterization team while they are performing their tasks.

The first step is to develop a customized site characterization plan, which is based on the specific circumstances of the *threat warning*. This customized plan may be adapted from a generic site characterization plan, which is developed as part of a utility's preparation for responding to contamination threats. The site characterization team will use the customized plan as the basis for their activities at the investigation site. After an initial evaluation of available information, it is necessary to identify an investigation site where site characterization activities will be conducted. During the development of the customized plan, it is important to conduct an initial assessment of site hazards, which is critical to the safety of the site characterization team and may impact the makeup of the team. If there are obvious signs of hazards at the site, then teams trained in hazardous materials safety and handling techniques, such as HazMat, may need to conduct an initial hazard assessment at the site and either "clear" the site for entry by utility

personnel, or the HazMat team may decide to perform all site characterization activities themselves. Obvious signs of hazards would provide a basis for determining that a threat is 'credible.' Furthermore, the site might be considered a crime scene if there are obvious signs of hazards, and law enforcement may take over the site investigation.

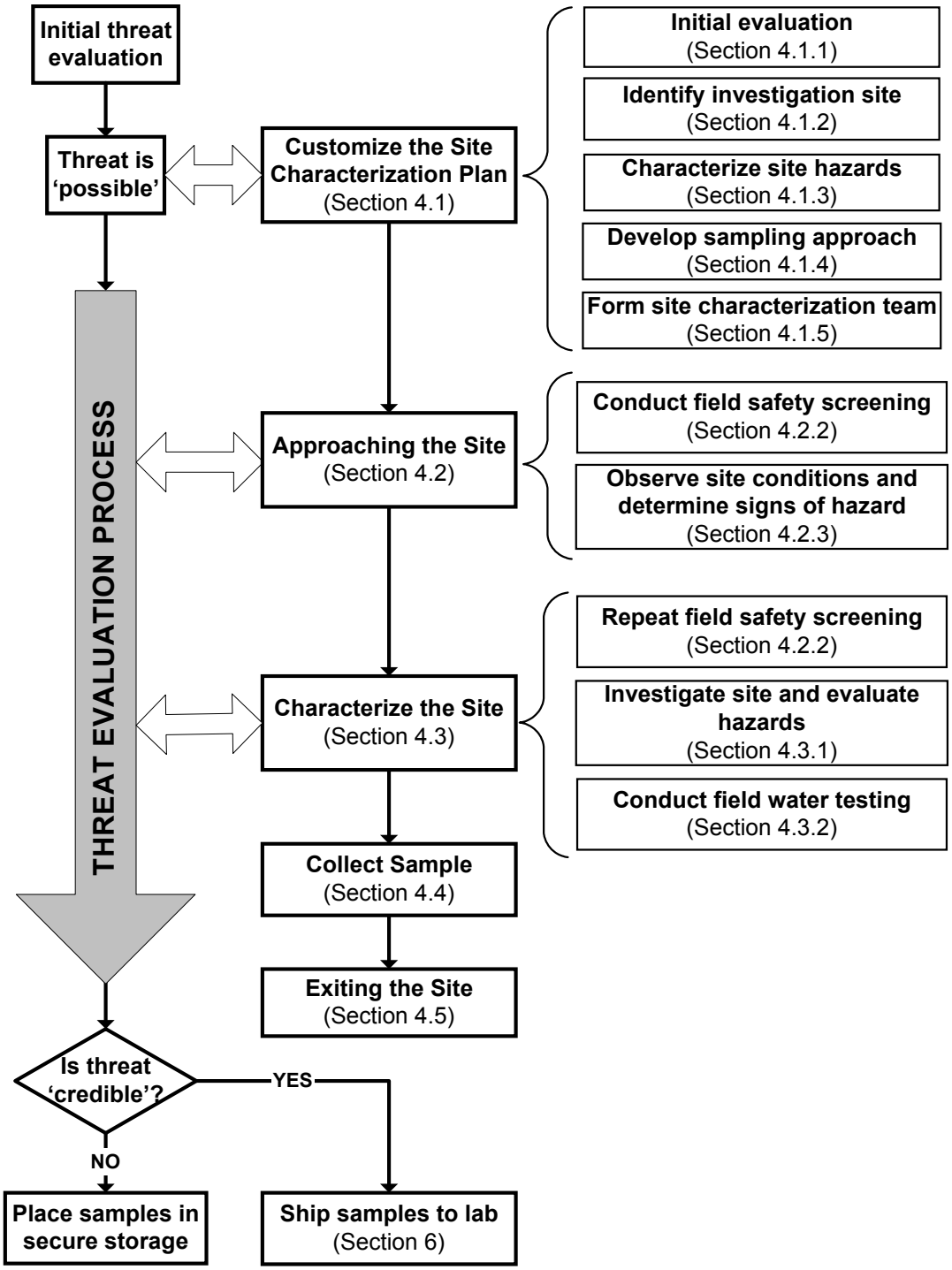


Figure 3-1. Overview of the Site Characterization Process

Upon arrival at the *site perimeter*, the team first conducts field safety screening and observes site conditions. The purpose of field safety screening activities is to identify potential environmental hazards that might pose a risk to the site characterization team. The specific field safety screening performed should be identified in the site characterization plan, and might include screens for radioactivity and volatile organic chemicals (VOCs). If the team detects signs of hazard, they should stop their investigation and immediately contact the incident commander to report their findings.

If no immediate hazards are identified during approach to the site, the incident commander will likely approve the team to enter the site and perform the site characterization. During this stage, the team will continue field safety screeningat the site, conduct a detailed site investigation, and perform rapid field testing of the water that is suspected of being contaminated.

Rapid field testing has three objectives: 1) provide additional information to support the threat evaluation process; 2) provide *tentative identification* of contaminants that would need to be confirmed later by laboratory testing; and 3) determine if hazards tentatively identified in the water require special handling precautions. The specific rapid field testing performed should be identified in the site characterization plan, and might include tests for chlorine residual and cyanide for example. Specific field testing performed should be based on the circumstances of the specific threat and should consider the training, experience and resources of the site characterization team. Negative field test results are **not** a reason to forgo water sampling (see below), since field testing is limited in scope and can result in false negatives.

Following rapid field testing, samples of the potentially contaminated water will be collected for potential laboratory analysis. The decision to send samples to a laboratory for analysis should be based on the outcome of the threat evaluation (Figure 3-1). If the threat is determined to be 'credible,' then samples should be immediately delivered to the laboratory for analysis per the guidance in Section 6. The *analytical approach* for samples collected from the site should be developed with input from the supporting laboratory(ies), based on information from the site characterization and threat evaluation (see Module 4 for guidance on developing an analytical approach). On the other hand, if the threat is determined to be 'not credible,' then samples should be secured and stored for a predetermined period in the event that it becomes necessary to analyze the samples at a later time.

At this point, response actions may be implemented to protect public health, as discussed in Module 2. However, if the threat is determined to be "not credible," then samples may be collected, preserved and stored in the event that it becomes necessary to analyze them later. Sample preservation is discussed below.

Upon completion of site characterization activities, the team should prepare to exit the site. At this stage, the team should make sure that they have documented their findings, collect all equipment and samples, and re-secure the site (e.g., lock doors, hatches and gates). If the site is considered to be a potential hazardous site or crime scene, there may be additional steps involved in exiting the site.

2.2 Roles and Responsibilities

The incident commander and the *site characterization team leader* are key personnel in site characterization. As discussed in Module 1, Section 4.4, the incident commander has overall responsibility for managing the response to the threat, and is responsible for planning and directing site characterization activities. The incident commander may also approve the site characterization team to proceed with their activities at key decision points in the process (e.g., whether or not to enter the site following the approach).

The site characterization team leader is responsible for implementing the site characterization plan in the field and supervising site characterization personnel. The site characterization team leader must coordinate and communicate with the incident commander during site characterization.

Depending on the nature of the contamination threat, other agencies and organizations may be involved or otherwise assume some responsibility during planning and implementation of site characterization activities. Various organizations that may be involved in site characterization are described below, with their potential roles and responsibilities. The incident commander has ultimate responsibility for determining the scope of the site characterization activities and the team makeup. Federal roles and responsibilities are dictated by the Federal Response Plan (FRP), which is described in Module 1, Appendix 6.2.

Water Utility – The water utility will be responsible for incident command(the *water utility emergency response manager* (WUERM) would be designated as the incident commander), unless another organization is designated. As incident commander, the WUERM would be responsible for planning and coordinating site characterization activities. Regardless of the organization responsible for incident command, the utility will be involved in site characterization activities. An employee of the water utility may be designated as the site characterization team leader. In cases where that responsibility is designated to another agency (e.g., HazMat), utility staff should be included on the site characterization team or as technical advisors to the team.

HazMat – Specialized response teams, such as HazMat, may assume responsibility for oversight of site characterization activities in situations where hazardous materials are suspected. In some situations, the HazMat team may limit their activities to characterization of site hazards and "clearing" the site for entry by utility personnel. The HazMat team may also elect to perform **all** site characterization activities with guidance from utility staff. The WUERM should understand how and under what circumstances HazMat teams might support site characterization activities.

Technical Assistance Providers – Other agencies, such as the *drinking water primacy agency*, US EPA hazardous material responders, or other specially trained response teams may assume responsibility for planning, oversight, and implementation of site characterization activities. Furthermore, this may provide the only means of performing site characterization for smaller utilities with limited resources. However, even at the smallest utility, the staff will at least need to play an advisory role during site characterization.

Laboratories – Laboratories will likely be responsible for the rapid analysis of samples collected by the site characterization team in response to a contamination threat. Thus, the laboratory(ies) should be engaged during both the hazard evaluation and site characterization activities if possible. The laboratory may provide the utility with sample kits to ensure that the sample containers are properly prepared and preserved for the methods and techniques that the laboratory would use in their analytical approach for unknown, or tentatively identified, contaminants in water samples. Furthermore, the laboratory will need information from site characterization to support the development of the analytical approach for a specific contamination threat. In some cases, the laboratory may be willing to send their staff to the site to assist with sample collection.

Local Law Enforcement Agencies – A law enforcement agency may assume responsibility for incident command in situations where criminal activity, excluding federal crimes, is suspected. In this case, law enforcement would likely manage the site in order to maintain the integrity of the crime scene while they proceed with their investigation. Local law enforcement and the utility should work together so that site characterization activities can be performed to determine if the threat is 'credible' or not, without compromising crime scene integrity.

Federal Bureau of Investigation (FBI) – FBI will assume responsibility for incident command when a federal crime, including terrorism, is suspected. As with local law enforcement, the FBI will maintain control of the site, and the utility will need to work with the FBI in a technical support role during site characterization. If FBI becomes involved and assumes command of the situation, they will make the credibility determination. Under these circumstances, site characterization is not as critical for threat evaluation but may be critical for determining the identity of the contaminant and the extent of contamination.

The site characterization activities presented in this module range from relatively simple activities, such as evaluating site conditions, to complex activities, such as field testing for unusual contaminants. The drinking water utility will need to decide in advance the extent of site characterization capabilities that they will develop within their own organization and those that would be provided by an external organization. For example, a drinking water utility may choose to develop a capability for performing the site evaluation and core field testing at low hazard sites. The utility may make arrangements with HazMat responders to provide support during the characterization of potentially hazardous site. The utility may also arrange with the contract lab to provide sample kits and sample containers. It is critical that the utility plan for those site characterization activities that they will take responsibility for, and make arrangements with agencies that will support the utility in the event that a situation exceeds the utility's resources and capability.

3 Planning for Site Characterization

This section describes the planning phase of site characterization and is divided into the following five subsections:

- Section 3.1, Safety and Personnel Protection: Summarizes basic safety practices appropriate for site characterization activities under low hazard conditions.
- Section 3.2, Sample Collection and Field Test Kits: Presents example designs for sample collection kits and field test kits, including a detailed discussion of the content of each.
- Section 3.3, Generic Site Characterization Plan: Describes how to develop a generic site characterization plan that may be customized in response to a specific contamination threat.
- Section 3.4, Evaluation of Baseline Water Quality Information: Discusses the importance of baseline data during the interpretation of the results of field testing and sample analysis.
- Section 3.5, Quality Assurance for Field Testing and Sampling: Provides general guidance regarding quality assurance activities that may be appropriate during site characterization activities.
- Section 3.6, Maintaining Crime Scene Integrity: Provides general guidelines for maintaining crime scene integrity during site characterization activities.

Providing training of staff involved in site characterization and sampling activities is critical. Responding to the site of a potential contamination incident is very different from routine inspection and sampling activities performed by utility staff. The equipment and safety procedures used at the site of a potential contamination incident may differ significantly from those used during more typical field activities. Providing staff training in the procedures presented in this module will help to ensure that they are properly and safely implemented during emergency situations (Module 1, Section 4.7 provides additional discussion of training needs).

3.1 Safety and Personnel Protection

Proper safety practices are essential for minimizing risk to the site characterization team and must be established prior to an incident in order to be effective. Field personnel involved in site characterization activities should have appropriate safety training to conform to appropriate regulations, such as OSHA 1910.120 (http://www.osha.gov), which deals with hazardous substances. If planners and field personnel do not conclude that these regulations are applicable to them, they may still wish to adopt some of the safety principles in these regulations. The following guidance is provided to help the user develop their own safety policies and practices. These safety policies should be consistent with the equipment and capabilities of the site characterization team and any applicable regulations.

The appropriate level of personal protection necessary to safely perform the site characterization activities will depend on the assessment of site hazards that might pose a risk to the site characterization team. An initial site hazard assessment will be performed during the development of a customized site characterization plan(see Section 4.1.3). The hazard assessment may be further refined during the approach to the site, based on the results of the field safety screening and initial observation of site conditions. Two general scenarios are

considered, one in which there are no obvious signs of immediate hazards, and one in which there are indicators of site hazards.

In **most** cases, the investigation site or suspected contamination site will not present a significant hazard to the site characterization team, and basic equipment and training will be sufficient to conduct site characterization activities safely. Under these conditions, it is presumed that any contaminants that might be present are confined to water and are present at dilute concentrations where the risk to personnel can be minimized through the use of good safety practices, including:

- **Do not** eat, drink, or smoke at the site.
- **Do not** taste or smell the water samples.
- **Do** use general personal protective equipment (PPE) such as splash-proof goggles, disposable gloves, proper footwear (i.e., no open toe or open heel shoes), disposable shoe covers, a chemical resistant, disposable lab coat, and long pants.
- **Avoid** all skin contact with the water, and if incidental contact does occur, immediately flush the affected area with clean water brought to the site for that purpose.
- Fill sampling containers **slowly** to avoid volatilization or aerosolization of contaminants.
- **Minimize** the time that personnel are on the site and collecting samples.

(Note that the PPE described above is only intended to minimize incidental contact with the contaminated water or chemical reagents used during sample collection or field testing).

Basic good safety practices such as those listed above should be incorporated into a set of concise safety guidelines for personnel responsible for performing site characterization activities. These guidelines may be formalized into a health and safety plan (HASP). Information on HASPs is available at http://www.ertresponse.com/health_safety/index.htm, along with an electronic expert system jointly developed by EPA and OSHA (http://www.osha.gov/dts/osta/oshasoft/ehasp/) to help determine the appropriate health and safety hazards necessary for a particular situation.

In some cases, obvious signs of hazard may be observed at the time the threat is discovered or during the approach to the site, as described in Section 4.2.3. Under these conditions, only personnel with proper equipment and training for response to hazardous situations should enter the site and perform characterization activities, such as HazMat teams, EPA On Scene Coordinators (OSCs) and their supporting contractors, or FBI hazardous materials response teams.

Hazardous site conditions may also require the use of specialized sampling techniques in order to manage the risk of incidental exposure during sampling, sample transport, or sample receipt at a laboratory. Furthermore, it may be necessary to develop a site-specific safety plan for work performed on the site. If the specific hazards are known or suspected, such a site-specific plan can be tailored to those hazards, and appropriate *personal protective equipment* (PPE) for specific chemical contaminants can be found at the Chemical Hazards Response Information System (CHRIS) at http://www.chrismanual.com.

While the absence of signs of hazards may indicate that there is minimal risk to the site characterization team, it is not a certainty. There are risks associated with any on-site activities,

whether they are related to the threat of intentional contamination or not. It is impossible to eliminate all risks, but risk can be managed through planning, training, and the use of proper techniques and procedures in the field.

3.2 Sample Collection Kits and Field Test Kits

Two types of kits are discussed in this section, sample collection kits and field test kits. Sample collection kits will generally contain all sample containers, materials, supplies, and forms necessary to perform sample collection activities. Field test kits contain the equipment and supplies necessary to perform field safety screening and rapid field testing of the water. Sample collection kits will generally be less expensive to construct than field test kits, and by constructing these two types of kits separately, sample collection kits can be pre-positioned throughout a system while the more expensive field test kits may be assigned to specific site characterization teams or personnel.

The design and construction of sample collection and field test kits is a planning activity, since these kits must be ready to go at a moments notice in response to a 'possible' contamination threat. In addition to improving the efficacy of the site characterization and sampling activities, advanced preparation of sample collection and field test kits offers several advantages:

- Sample collection and field test kits can be standardized throughout an area to facilitate sharing of kits in the event of an emergency that requires extensive sampling.
- Collection of a complete sample set is more likely to be achieved through the use of pre-designed kits.
- Sample collection kits can be pre-positioned at key locations to expedite the sampling process.
- Personnel responsible for site characterization can become familiar with the content of the kits and trained in the use of any specialized equipment.

3.2.1 Sample Collection Kits

Table 3-1 presents an **example** of a sample collection kit, while Table 3-2 provides a detailed listing of the sample containers included in the kit, and which are consistent with the analytical protocols presented in Module 4. The sample collection kit includes:

- Large plastic container for holding sample kit supplies
- Field resources and documentation
- General sampling supplies, including sample containers
- Pathogen sampling supplies
- Reagents
- Safety supplies

The sample collection kit described in this section is intended to illustrate the type of materials and supplies that might be useful during sampling activities; however, the design of a specific kit should be tailored to the needs and sampling objectives of the user. Furthermore, other organizations may need to be consulted in the design of a sample collection kit. For example, the laboratory may wish to provide sample containers and reagents that are consistent with the analytical approach for water samples potentially containing non-target analytes.

Table 3-1. Example Design of an Emergency Water Sample Collection Kit

Item	Quantity	Notes
Field Resources and Documentation		
Field guide	2	Resource for field personnel
Health and safety plan	2	If required for the site
Sample labels	48	Waterproof (filled out in advance, if possible)
Sample documentation forms	24	For recording sample information
Custody tape (or seals)	2 rolls	Used on sample or shipping containers
Chain of custody forms	24	For documenting sample custody
Lab marker	2	Waterproof, 1 red, 1 black
General Sampling Supplies		
Sample containers	Table 3-2	For collecting samples
Device for grab sampling	1	For sampling large water bodies
10 liter HDPE container	4	For collection of large volume water samples
Lab grade tape	3 rolls	For temporary labeling in the field
Miscellaneous glassware	N/A	Beakers, graduated cylinders, spatula, etc.
Collapsible cooler	1	For sample storage
Rigid shipping container	1	For shipping by overnight service if needed.
1 qt. zippered freezer bags	1 pack100	For double bagging ice and sample containers
Thermometer	2	For checking water temperature
Paper towels	2 rolls	Wiping wet containers and containing spills
Pathogen Sampling Supplies		
Tubing and clamp	1	For sample tap flushing, etc.
Stopwatch & graduated cylinder	1	For measuring flow rate
Ultrafiltration apparatus	1	For concentrating pathogen samples
Reagents (may need to be kept separate from the rest of the kit)		
Laboratory grade water	5 liters	For sample dilution in the field
Sodium thiosulfate crystals	100 grams	For water sample dechlorination
Ascorbic acid	100 grams	For water sample dechlorination
Sodium sulfite crystals	100 grams	For water sample dechlorination
Potassium dihydrogen citrate	100 grams	For carbamate preservation
6 Molar ACS grade hydrochloric acid (HCl)	25 mL	In dropper bottle for preservation of samples for organic analyses
6 Molar trace metal-grade nitric acid (HNO_3)	25 mL	In dropper bottle for preservation of samples for trace metals analysis
10 Normal Sodium hydroxide (NaOH)	25 mL	In dropper bottle for preservation of samples for cyanide analyses
pH paper in ranges from 0 - 4 and 10 - 14	50 strips	For checking the pH of samples preserved with acid or base (sensitive to 0.5 pH units)
Safety Supplies		
Splash resistant goggles	2	One per individual (minimum)
Disposable gloves	6 pairs	Nitrile or polyethylene, powder-free
Disposable shoe covers	2 pairs	One pair per individual (minimum)
Disposable laboratory coats	2	One per individual (minimum)
Clear, heavy duty plastic trash bags	4	For disposal of lab coat, gloves, etc.
Rinse water	20 liters	For general use and first aid
Antiseptic wipes	1 container	For cleaning hands, sample containers, etc.
Bleach solution (at least 5%)	1 gallon	For decontamination if necessary
Squirt bottle	2	For use with rinse water or lab grade water
First aid kit	1	For general first aid
Flashlight/headlamp	3	For working at night or in dark locations

Table 3-2. Samples Containers for Emergency Water Sample Collection Kit

Sample Type	Container Size	Container Type	No.	Dechlorinating Agent	Preservative	Analytical Technique	Reference Methods
CHEMISTRY - BASIC SCREEN (Established Techniques)							
Organic Analytes							
Volatiles	40 mL	Glass w / Teflon faced septa	5	Ascorbic acid	1:1 HCl to pH < 2 See method.	P&T – GC/MS	EPA 524.2, 8260B
						P&T – GC/PID/ELCD	EPA 502.2, 8021B
Semi-volatiles	1 L	Amber w / Teflon-lined screw caps	4	Sodium sulfite	6M HCl. See method.	SPE GC/MS	525.2, 8270D/3535
Quarternary nitrogen compounds	1 L	Amber PVC or silanized glass	4	Sodium thiosulfate	Sulfuric acid to pH 2	SPE HPLC - UV	549.2
Carbamate Pesticides	40 mL	Glass w / Teflon faced septa	4	Sodium thiosulfate	Potassium dihydrogen citrate sample pH to ~3.8	HPLC-fluorescence	531.2
Inorganic Analytes							
Metals/Elements	125 mL	Plastic (i.e. HPDE)	2	None	Trace metal grade nitric acid. See method.	ICP-MS	200.8
						ICP-AES	200.7
						AA	200.9
Organometallic compounds	125 mL	Plastic (i.e. HPDE)	2	None	Nitric acid to pH $\leq$2. See method.	AA – cold vapor manual	245.1
						AA – cold vapor automater	245.2
Cyanide	1 L	Plastic	2	Ascorbic acid	Sodium hydroxide to pH 12. See method.	Titrimetric Spectrophotometric	335.2
						Colorimetric UV	335.3
Radiological	2 L	Plastic	2	None	None - mark samples not preserved	Gross alpha, gross beta, gamma isotopes, specific radionuclides	900 Series

Sample Type	Container Size	Container Type	No.	Dechlorinating Agent	Preservative	Analytical Technique	Reference Methods
CHEMISTRY - EXPANDED SCREEN (Exploratory Techniques)							
Unknown organics (volatile)	40 mL	Glass w / Teflon faced septa	5	None	None - mark samples not preserved	P&T-GC/MS	See Module 4
Unknown organics (general)	1 L	Amber Glass	4	None	None - mark samples not preserved	**Prep**: SPE, SPME, micro LLE, direct aqueous injection, headspace **Analysis**: GC/MS, GC, HPLC, LC-MS	See Module 4
Unknown inorganics	1 L	Plastic	2	None	None - mark samples not preserved	ICP-MS	See Module 4
Immunoassays	1 L	Amber Glass	2	Consult manufacturers instructions	Consult manufacturers instructions	Consult manufacturers instructions	None
PATHOGENS - EXPANDED SCREEN (Established and Exploratory Techniques)							
Pathogens - culture	100 mL	HDPE (plastic)	2	Thiosulfate	TBD	Per target pathogens	See Module 4
Pathogens - PCR	100 mL	HDPE (plastic)	2	Thiosulfate	TBD	Per target pathogens	See Module 4
BASELINE WATER QUALITY PARAMETERS (See Section 3.4)							
Water quality: bacteria	250 mL	Plastic	1	Thiosulfate	None	Fecal coliforms, E-coli,	Standard methods
Water quality: chemistry	1 L	Plastic	1	None	None - mark samples not preserved	Conductivity, pH, alkalinity, hardness, turbidity	Standard methods
Surrogates	1 L	Amber glass	2	None	None - mark samples not preserved	Total organic carbon, ultraviolet absorbance, color, chlorine demand	Standard methods
Toxicity	125 mL	Glass	2	Consult manufacturers instructions	Consult manufacturers instructions.	Rapid toxicity assay (several vendors)	None

The field resources and documentation listed in Table 3-1 includes field guides, forms, and labels intended to support sampling activities. The field guide is a resource containing simple flow-charts, checklists, reporting forms, and concise summaries of field protocols to assist the team in performing activities such as field testing and sampling. The guide also includes forms for sample documentation and chain of custody (also see Appendices 8.4 and 8.5, respectively). In some cases, a HASP may be required, and may be generic or site-specific.

The sampling supplies listed in the table include sample containers as well as miscellaneous glassware, and supplies used during sample collection. Several clean 10-liter, high density polyethylene (HDPE) containers, such as collapsible cubitainers, are included in the kit in the event that large volume water samples need to be collected. Other supplies such as tape, spatulas, pipette bulbs, foil, etc., should be included based on experience with other sampling activities. A collapsible cooler can be used to keep samples chilled following collection until they are transferred to a refrigerator, packed for shipment to a laboratory, or delivered to a designated recipient.

Note that shipment to a remote laboratory via an overnight service will require a **rigid** shipping container, such as a cooler; furthermore, certain hazardous samples may only be shipped in approved containers, as discussed in Section 6. If samples will be taken back to the utility prior to shipment, then the rigid shipping container does not need to be included in the sample kit. Frozen ice packs may be included with the sample kit to chill the samples, but a more practical approach may be to fill sealable plastic freezer bags with ice and seal them in a manner to prevent leaking (e.g., double bag the ice and seal with waterproof tape).

Special supplies are required for the field collection of samples for analysis of unknown pathogens. The *ultrafiltration* apparatus is used in the field to concentrate pathogens in a water sample in order to improve method sensitivity and reduce the sample volume to a manageable size (see Section 4.4.3 for a description of the ultrafiltration apparatus). The tubing and clamp may be used to aid in flushing sample taps, but should not be used for the collection of samples for organic analysis, as materials may leach from the plastic and interfere with analysis. The stopwatch and plastic graduated cylinder are used to measure the flow rate from the ultrafiltration apparatus, if necessary. Once the ultrafiltration apparatus is standardized, it may not be necessary to measure flow rates in the field.

The sample containers in the kit are listed in Table 3-2, which describes the container size and type, preservatives and dechlorinating agents, and specific analyses to be performed on the sample. Four subsets of sample containers are shown in Table 3-2 to align with the analytical approach presented in Module 4: a basic chemistry screen, an expanded chemistry screen, a pathogen screen, and general water quality parameters.

Since the analyses used in the basic chemistry screen are based on standard methodologies, the requirements for sample containers and preservation are well documented. The expanded chemistry screen relies on exploratory techniques, and samples for these analyses should be collected without preservation.

The sample containers for pathogen analysis include containers for general bacteriological water quality indicators and 100 mL plastic containers for the collection of concentrated aliquots for analysis of pathogens using culture and PCR techniques. Alternately, one 250 mL sample may be collected for pathogen analysis and split for PCR and culture analysis in the lab. If ultrafiltration is not performed in the field, the alternate approach for pathogen sampling is to collect one or more 10-liter containers such that the water can be transported to the laboratory for filtration, extraction, and analysis. Sample containers for baseline water quality parameters will depend on the specific parameters to be analyzed, and a few examples are shown in the table. Table 3-2 illustrates the types of sample containers that might be included in a sample collection kit; however, the specific containers included in the kit should be determined in consultation with the laboratory that would be analyzing the samples.

The laboratory should be consulted regarding appropriate sample preservation that is consistent with the types of analyses that will be performed. In general, there are three options for sample preservation: no preservation, minimal preservation, and preservation according to a standardized method.

- No preservation – samples are simply collected in clean glass or plastic containers. This approach may be appropriate if the samples will be analyzed within 24 hours of sample collection. The advantage of this approach is that sampling is simplified and maximum flexibility during sample analysis is maintained. The disadvantage is that samples must be quickly analyzed, and some contaminants may degrade even in a short time period. Note that samples collected for the expanded chemistry screen may not be preserved in any case since many of these techniques are not based on standardized methods with documented preservation requirements.

- Minimal preservation – samples are preserved according to some preservation strategy other than that dictated by the method. For example, a dechlorinating agent may be added to all samples. If this approach is used, the laboratory should be asked to confirm that the preservative used does not interfere with the analysis.

- Preservation according to the method – this approach is recommended if the samples are to be held for any appreciable time, or in situations where a particular contaminant is suspected. Table 3-2 lists specific preservatives and dechlorinating agents for analytes sampled according to EPA method specifications. The methods should be consulted for details regarding sample preservation and holding times.

Regardless of the method of preservation used, the preservatives added to a sample must be clearly communicated to the laboratory. If method specified preservation techniques are not used during sample collection, the laboratory may need to consult the method to determine if they need to add a reagent or adjust the sample pH prior to analysis.

The reagents listed in Table 3-1 include preservatives, dechlorinating agents, and laboratory grade water. The kit also includes pH paper that may be used to test the pH of samples that undergo pH adjustment. It is generally recommended that the preservatives and dechlorinating agents, if used, be added to the sample containers in the proper amounts during preparation of the

sample kit, as this will simplify sample collection and minimize the number of reagents that need to be taken into the field. Where both a dechlorinating agent and an acid is required for preservation, it is recommended that the dechlorinating agent be added to the empty container before adding the sample, then adding the sample, and finally adding the acid, to avoid a reaction of the acid and dechlorinating agent before sample is added. If it is necessary to take preservatives or dechlorinating agents into the field, it is desirable to store them separately from the rest of the kit since they may expire more quickly than other materials in the kit.

Laboratory grade water (distilled or deionized water) is primarily for sample dilution in the field, if necessary; however, it may have other uses such as conducting field testing. Laboratory grade water should **not** be stored in the kit, but rather collected fresh from the laboratory (or from a commercial source) as the site characterization team departs for the investigation site. Laboratory grade water should only be placed into clean organic-free glass or Teflon containers.

The safety supplies listed in Table 3-1 include splash-proof safety goggles, disposable nitrile or polyethylene gloves (without powder), chemical resistant disposable lab coats, and disposable shoe covers. This basic PPE is intended to protect samplers from strong acids and bases used for sample preservation, as well as to reduce the risk of incidental contact with the water while collecting samples or performing field tests. This PPE is appropriate for sites that are characterized as low hazard (see Section 4.1.3). Upon exiting the site, the heavy-duty plastic trash bag is used to collect any disposable PPE and supplies used on site.

The 20-liter reservoir of rinse water listed in Table 3-1 can be used to rinse skin or other materials accidentally exposed to the suspect water. Tap water collected from an unaffected area can be used for this purpose. This water does not need to be included in the kit, rather the reservoir can be stored in the utility vehicle that would be used by the site characterization team. Rinse water should **not** be used for sample dilution or other activities where laboratory grade water is required. The antiseptic wipes are included for cleaning hands or wiping the outside of sample containers. A one-gallon container of bleach may be included in the kit in case more aggressive decontamination is necessary.

Emergency water sampling kits are likely to receive little actual use and may remain in storage at predetermined locations for extended periods, during which time reagents may expire. To ensure that sample collection kits are properly maintained, it is recommended that they be dated and periodically refurbished on at least an annual basis. At a minimum, sample containers with preservatives should be replaced with fresh containers, and the contents of the kit should be inspected to ensure that it is complete and all items are still functional. Expired kits can be used in field drills, which provides an opportunity to train staff and verify that the equipment is functional.

The sample kit presented in Table 3-1 contains the basic equipment necessary to collect water samples from locations with a hose bib, faucet, or other sample tap. Other equipment may be necessary to collect samples from sites that are not equipped with suitable sample taps. For example, in order to safely sample from fire hydrants, hoses, couplings, pressure reducers, and valves may be needed. Likewise, some distribution system storage tanks may not have sample taps in locations conducive to collecting representative samples from the body of water in the

tank. This represents a similar challenge to that of collecting a representative sample from a large body of water, such as a reservoir. Thus the practices and equipment used for source water sampling may be applicable to sampling large tanks and reservoirs in the distribution system. Techniques for sampling from large or deep bodies of water may require the use of a boat, depth samplers, Van Doren samplers, or bacon bomb samplers, among others. Typical equipment for sampling from source waters is listed in the U.S. EPA, Environmental Response Team SOP #2013 (http://www.ertresponse.com/sops/2013-r10.pdf).

3.2.2 Field Test Kits

Two types of field tests will potentially be performed during site characterization: field safety screening and rapid field testing of the water. Field safety screening and rapid field testing procedures are discussed in Sections 4.2.2 and 4.3.2, respectively. This section describes the equipment that is used to support these activities.

While different equipment may be used for safety screening and water testing, it's efficient to construct field test kits that contain equipment for both. The field test kit should include the field detectors used in safety screening or rapid water testing, supporting equipment, reagents, spare parts (including batteries), and documentation necessary to perform field testing. It is also recommended that the field test kits be constructed such that they are separate from sample collection kits, due to relatively high cost of field test kits. This approach allows numerous sample collection kits to be pre-positioned at strategic sites, while a smaller number of field test kits can be assembled and assigned to specific teams or personnel.

Table 3-3 lists the generic types of screening and detection devices and kits that could be included in a field test kit. The core field test kit includes the equipment necessary to conduct the recommended minimum level of field safety screening and rapid water testing. Additional technologies that might be used to perform *expanded field testing* are listed in the second section of the table. The target parameter for screening and rapid water testing may be a specific contaminant, a contaminant class, or a general indicator of potential contamination. The class indicates whether the technology is suitable for field safety screening, rapid water testing, or both. The methodology describes the general principle of detection for the technology.

Due to the wide range of available field testing equipment, specific devices and vendors are not listed here; however, there are sites that do provide a detailed listing of commercially available detection technologies, such as http://www.epa.gov/safewater/security/guide/index.html, http://www.ojp.usdoj.gov/nij/pubs-sum/190747.htm, and http://www.ojp.usdoj.gov/nij/pubs-sum/184449.htm. Detailed verification reports for detectors that have undergone independent testing through the Environmental Technology Verification (ETV) program are available at http://www.epa.gov/etv.

The core field test equipment includes a radiation detector capable of analyzing for alpha, beta, and gamma radiation for field safety screening. This detector is used to quickly identify radiological hazards or eliminate them from consideration. If levels of radioactivity are detected that pose an immediate risk to life or health, the site would be characterized as a radiological hazard (see Section 4.1.3). Without a radiation detector, it may be impossible to determine

whether or not the site has been contaminated with radioactive material. Typical the components that form the detector are sold separately and include a probe (e.g., a pancake G-M probe) and a rate meter. Radiation detectors are an established technology, widely used by responders, simple to operate, relatively inexpensive (<$1,000), and available from a variety of vendors. Examples of radiation detectors and related information can be found at www.ludlums.com and www.geigercounters.com.

Water is an effective shield to radiation, and weak forms of radiation may not penetrate water at all. Thus, a negative result from a typical pancake G-M probe (designed to detect radiation in air) does not provide assurance that the water is free of radioactive contamination. However, there are devices, such as sodium iodine probes, which are designed to detect radiation (beta and gamma) in water.

Cyanide detectors are included in the core field kit to quickly rule out, or tentatively identify, cyanide as a potential contaminant in the water. Most commercially available cyanide test kits are based on either colorimetric or ion selective electrode technologies. Several commercially available cyanide detectors were verified by EPA's ETV program in 2003, and the verification reports can be found at http://www.epa.gov/etv/.

Table 3-3. Core and Expanded Field Test Kits

CORE FIELD TEST KIT			
Target Parameter	**Class**	**Methodology**	**Comments**
Radioactivity (alpha, beta, and gamma)	Primarily a Safety Screen	G-M probe and meter	May be expanded to water testing with a special probe.
Cyanide	Water Testing	Colorimetric or ion selective electrode	Tests water for cyanide ion, but not combined forms.
Chlorine residual	Water Testing	Colorimetric	Absence of residual may indicate a problem.
PH/conductivity	Water Testing	Ion selective electrode	Abnormal pH or conductivity may indicate a problem.
EXPANDED FIELD TEST KIT			
Target Parameter	**Class**	**Methodology**	**Comments**
General hazards	Safety Screen	HazCat (explosives, oxidants, etc.)	Should be performed by trained HazMat responder.
Volatile chemicals	Safety Screen	Sniffer-type devices	Detects chemicals in air.
Chemical weapons (VX, sarin, etc.)	Both	Enzymatic / colorimetric	Many kits may also detect certain pesticides.
Water quality parameters	Water Testing	Variable (e.g., ion probes, colorimetric)	Kits available for a variety of common parameters.
Pesticides (OP and carbamates)	Water Testing	Immunoassays	Quick and simple to use.
VOCs and SVOCs	Water Testing	Portable GC/MS	Expensive, but expands field capability for chemicals.
Biotoxins (ricin, botulinum, etc.)	Water Testing	Immunoassays	Quick and simple to use.
Pathogens (tularemia, anthrax, plague, etc.	Water Testing	Immunoassays and PCR	Preconcentration will increase sensitivity.
Toxicity	Water Testing	Inhibition of biological activity.	Need to establish a baseline.

Chlorine residual measurements (both free and total) are of particular interest in distributed drinking water since the absence of a residual disinfectant is undesirable under any circumstance. Chlorine residual test kits and pH meters are established technologies that are widely used in the drinking water treatment industry. Chlorine residual test kits are typically based on colorimetric techniques, while pH instruments are based on ion-selective electrodes. Some pH instruments can also measure conductivity, which is another useful indicator of water quality changes (assuming that a baseline for conductivity has been established). These general parameters are included in the core field test kit as general indicators of water quality, and deviations from established baseline values (see Section 3.4.1) may indicate a potential problem.

The equipment listed under the expanded field test kit section of Table 3-3 is intended to provide an indication of the other types of detection technology that are currently available and which might be considered for inclusion in a field test kit. These additional detection technologies can provide additional information for characterizing hazards at a particular site (see Section 4.1.3) or increasing the range of contaminants that can be tentatively identified during rapid field testing of the water. Expanded field testing might include volatile chemicals, chemical weapons, additional water quality parameters, pathogens, biotoxins, and general toxicity. The technologies may be relatively simple and inexpensive, as is the case for many immunoassay test kits, or complex and expensive, as is the case for mobile GC/MS instruments. VOC sniffer devices may warrant special consideration as they are commonly used in environmental monitoring, are relatively easy to use, and can provide a rapid indication of potential volatile hazards.

Many technologies and detectors are commercially available that could be used for expanded field testing. **However, few of these technologies have undergone a thorough and independent performance evaluation. The use of field testing technologies for which performance has not been characterized is strongly discouraged.** False positive or false negative results from field testing can result in inappropriate decisions with potentially significant consequences. Some utilities may choose to perform their own evaluation of a field testing technology in order to characterize the performance of the detector so that it can be used with confidence during a site characterization activity.

EPA's ETV program is planning to evaluate several of these technologies. Toxicity assays were evaluated in the summer of 2003, and there are plans to evaluate immunoassay kits and field PCR systems by early 2004. Potential users of these technologies are strongly encouraged to review the ETV reports prior to making a decision regarding the implementation of any of these monitoring technologies. It is important to note that ETV is **not** a certification program and does **not** approve technologies. Rather it is a program for the independent evaluation of monitoring and detection equipment that simply reports the results of the verification study for a given technology.

As with sample collection kits, field test kits must be maintained so that the equipment and chemical reagents are in proper working order when the kits are needed. This requires proper calibration of instruments, ensuring that all reagents are fresh, checking batteries, and conducting any other maintenance or operational checks recommended by the equipment manufacturer. Furthermore, it is critical to provide staff training in the actual use of any field technology that

will be used to support site characterization activities in response to contamination threats. This can be accomplished through field exercises or incorporation of the field testing technology into routine monitoring activities. The latter will also provide an opportunity to develop baseline information for the monitored parameters. Such baseline data are important for interpreting field testing results in the event of a threat (see Section 3.4).

3.3 Generic Site Characterization Plan

A site characterization plan is developed to provide direction and communication between the incident commander and the site characterization team, which will facilitate the safe and efficient implementation of site characterization activities. The plan should be developed expeditiously since the site characterization results are an important input to the threat evaluation process. The rapid development of a site characterization plan can be facilitated by the development of a **generic** site characterization plan**,** which is easily customized to a specific situation. While the circumstances of a particular threat warning will dictate the specifics of a **customized** site characterization plan, many activities and procedures will remain the same for most situations, and these common aspects can be documented in the generic site characterization plan. Potential elements of a generic plan include: pre-entry criteria, communications, team organization and responsibilities, safety, field testing, sampling, and exiting the site.

Pre-entry criteria define the conditions and circumstances under which site characterization activities will be initiated and the manner in which these activities will proceed. At each stage of the process (i.e., approach to the site, on-site characterization activities, sample collection, and exiting the site), specific criteria may be defined for proceeding to the next stage. The pre-entry criteria may also specify the general makeup of the site characterization team under various circumstances. For example, under low hazard conditions utility teams may perform site characterization, while specially trained responders might be called upon to assist in the case of potentially hazardous conditions at the site. The criteria developed for a particular utility should be consistent with the role that the utility has assumed in performing site characterization activities.

The generic plan should define communication processes to ensure rapid transmittal of findings and a procedure for obtaining approval to proceed to the next stage of site characterization. It is advisable for the site characterization team to remain in constant communication with the incident commander for the entire time that they are on site. The plan should provide an approval process for the team to advance through the approach and on-site evaluation stages of the characterization, to ensure that the team is not advancing into a hazardous situation. Communication devices (e.g., cell phone, two-way radio, or panic button) can be used to alert incident command of problems/observations encountered in the field. The communication section of the generic plan should also discuss coordination with other agencies (e.g., law enforcement, fire department) and contingencies for contacting HazMat responders.

Field testing and sampling may be handled in the generic plan by presenting a menu that covers all potential options available to the utility, based on both internal and external capabilities. In developing a customized plan, the incident commander can simply check off the field tests and

sampling requirements that are appropriate for the specific situation. The site characterization plan may also need to be revised in the field based on the observations of the team.

Many of the elements of a generic site characterization plan are captured in the "Site Characterization Plan Template" (see Appendix 8.1). The plan is customized by simply filling in the form based on the specific circumstances of the threat.

3.4 Evaluation of Baseline Water Quality Information

Baseline water quality information is derived from routine monitoring data and used to characterize typical levels of a particular contaminant or water quality parameter. While there are no requirements to develop baseline water quality information, it can be a valuable resource when interpreting the results from site characterization and laboratory analysis, specifically:

- The results of general water quality parameters, such as pH, chlorine residual, or conductivity, among others, should be compared against a baseline to determine whether or not the results represent a significant deviation from typical levels.
- A positive result for a specific contaminant may need to be compared against typical background levels in order to properly interpret the results.

Since each of these applications of baseline data has different requirements, they are discussed separately in the following subsections.

3.4.1 General Water Quality Parameters

General water quality data collected during the on-site investigation and subsequent sample analysis may indicate water contamination if the results differ from an established baseline or typical water quality values. In order for such a comparison to be made, it is necessary to establish a baseline for the water quality parameter(s) of interest. Some parameters vary as a function of time and position in the system while others may experience seasonal fluctuations. These normal variations should be captured in the baseline data. Two approaches for establishing a general water quality baseline are:

- Evaluate historical water quality monitoring data.
- During site characterization performed in response to a specific threat, baseline monitoring for target water quality parameters may be performed in an area of the distribution system that is not expected to fall within the potentially contaminated area.

Many water utilities routinely collect data that could be used to establish a baseline; however, this data would need to be analyzed and reduced to **information** that can be readily interpreted and used during an emergency situation. Trend charts and statistical summaries are two approaches for summarizing baseline water quality data.

In addition to using historical water quality data to establish a baseline, monitoring of unaffected sites may be used for comparison with water quality data collected from the potentially contaminated area. The unaffected site might be upstream or downstream of the potentially contaminated area, and ideally it would be hydraulically isolated from this area. However, the

results of supplemental baseline monitoring must consider typical water quality variations that occur at different locations within a distribution system.

A baseline can be established for any water quality parameter that is routinely monitored. The following list of routinely monitored water quality parameters illustrates factors that may be considered when establishing a baseline:

- pH of the distributed water is determined by the pH of the finished water at the entry point to the distribution system. In well-buffered waters, pH will typically remain fairly constant throughout a distribution system if the water is in equilibrium with the pipe material; however, it may vary if there are corrosion problems.

- Conductivity of the distributed water is determined by the conductivity of the finished water at the entry point to the distribution system. It will typically remain fairly constant throughout a distribution system if the water is in equilibrium with the pipe material; however, it may vary if there are corrosion problems.

- Chlorine/chloramine residual levels vary as a function of temperature, pH, degree of nitrification, pipe wall demand (i.e., from biofilm or corrosion), and distribution system residence time (i.e., water age). The initial residual is established at the plant by the disinfectant dose and oxidant demand of the water. Oxidant demand will vary as a function of water quality, and typically experiences seasonal fluctuations. The use of disinfectant booster stations in the distribution system must also be considered when evaluating baseline residual data.

- Total organic carbon (TOC) levels in the distribution system will remain relatively constant with respect to the finished water TOC. However, use of strong oxidants, such as ozone, can increase the biodegradable fraction of TOC, potentially resulting in greater variability in TOC levels in the distribution system.

- UV absorbance is typically used as a surrogate for TOC, but is more indicative of the aromatic fraction of TOC. UV absorbance will experience variations similar to TOC, and UV absorbance is also impacted by oxidants and disinfectants used in water treatment.

Another factor to consider when establishing a baseline for distribution system water quality is the potential for blending of water quality from different treatment plants. If multiple treatment plants feed the distribution system, the water quality will be a function of the blending ratio of the water from the different plants, in addition to the other factors described above. The task of establishing a baseline for such systems is further complicated by the fact that the blending ratios will vary both spatially and temporally.

3.4.2 Background Levels of Specific Contaminants

The second application of baseline data is to support the interpretation of the site characterization results for a specific contaminant. If a contaminant is tentatively identified or *analytically confirmed*, it may be prudent to compare the results to baseline concentrations of that

contaminant in the distribution system. This would be particularly important for typical water contaminants (such as cyanide, arsenic, specific disinfection byproducts, certain pesticides, *E. coli*, etc.). As with general water quality parameters, there are two approaches for estimating baseline levels of a specific contaminant in a distribution system:

- Evaluate historical monitoring results for the specific contaminant, if available.
- During site characterization performed in response to a specific threat, sampling for the specific contaminant may be performed in an area of the distribution system that is not expected to be contaminated.

In general, few contaminants of concern are monitored frequently enough to provide sufficient data to estimate a baseline. Typically, contaminants would only be monitored if required for compliance with drinking water standards, or if unregulated contaminants are known to occur in the finished water and are of significant importance or interest to the utility. When such data are available, it should be compiled and summarized to produce information that can be used to estimate baseline occurrence in the event of an emergency (e.g., using trend charts or statistical summaries). When compiling historic data, the baseline information should also identify any contaminants that are known to **not** occur in the finished water.

Assuming that field test kits are developed during planning for site characterization activities, as discussed in Section 3.2.2, utilities will know those contaminants that will be screened for in the field. In these cases, a utility may choose to integrate field testing for these contaminants into routine monitoring programs in order to generate data that can be used to establish a baseline for the specific contaminant. Additional benefits of routine field testing include exercising the equipment to ensure that it is calibrated and in proper working order and that the staff have an opportunity to become familiar with the operation of this equipment.

If a specific contaminant is identified and historic baseline occurrence data are not available, baseline sampling for the suspected contaminant might be performed to determine if the contaminant is present (and at what concentration) in non-affected areas of the system. Baseline sampling must be performed at a location that is located outside the contaminated area but which is also representative of the area that may be contaminated. For example, if multiple treatment plants feed a common distribution system, baseline sampling might be performed at a location that is fed by the same treatment plant that feeds the potentially contaminated area but in a different pressure zone.

While it may generally be assumed that a contaminant found near typical background levels is just background, this may not always be the case. Another possibility is that sampling only picked up the tail of a transient slug of a contaminant that was introduced at another point in the system at much higher levels. Other information from the threat evaluation process (Module 2) should be considered when making a determination between these two possibilities. For example, there may be physical evidence at the investigation site indicating potential contamination, in which case one might consider the possibility that the low level concentration is the tail of a larger slug. In this case, field testing and/or sampling for the specific contaminant at additional investigation sites may be appropriate.

3.5 Quality Assurance for Field Testing and Sampling

Because of the diversity of potential field testing and sampling activities during site characterization, there may be no specific quality assurance (QA) activities which apply to all sampling procedures. However, the following general QA principles would apply in most cases and are consistent with the QA guidelines published by EPA's Environmental Response Team (http://www.ertresponse.com/sops/2013-r10.pdf):

- All data should be documented on field data sheets or within site logbooks.
- All instrumentation should be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities should occur prior to site characterization and documented.
- Any relevant QA principles and plans specific to the particular water utility or responding organization should be observed.
- Additional QA principles are contained within the sampling guidelines presented in Section 4.4. It should be noted that these sampling guidelines also have various quality control (QC) elements built in, and these QC elements are often documented in the specific analytical methods.

3.6 Maintaining Crime Scene Integrity

The suspected contamination site that is the focus of site characterization activities could potentially become the scene of a criminal investigation. If law enforcement takes responsibility for incident command because they believe a crime has been committed, they will control the site and dictate how any additional activities, such as site characterization, are performed. In cases in which the utility is still responsible for incident command, it may still be prudent to take precautions to maintain the integrity of the potential crime scene during site characterization activities. The following guidelines for maintaining crime scene integrity are provided, although this should not necessarily be considered an exhaustive list:

- If there is substantial physical evidence of contamination at a site, the threat will likely be deemed 'credible' from a utility and a law enforcement perspective. In this case, law enforcement may take control of the site and limit the activities performed by other organizations at the site.
- Substantial physical evidence of contamination might include discarded PPE, equipment (such as pumps and hoses), or containers with residual material. Special care should be taken to avoid moving or disturbing any potential physical evidence.
- Evidence should not be handled except at the direction of the appropriate law enforcement agency. Specially trained teams from the law enforcement community are best suited (and may be jurisdictionally required) for the collection of physical evidence from a contaminated crime scene.
- The collection of physical evidence is not generally considered time sensitive; however, site characterization and sampling activities are time sensitive due to the public health implications of contaminated water. Thus, collection of water samples may precede collection of physical evidence, and care must be taken not to disturb the crime scene while performing these activities. If samples can be collected outside of the boundaries of the suspected crime scene, it may avoid concerns about the integrity of the crime scene.

- Water samples collected for the purpose of confirming/dismissing a contamination threat and identifying a contaminant could potentially be considered evidence and should be handled accordingly.
- Since the analytical results may be considered evidence as well, it is important to use a qualified laboratory for analytical support (see Module 4). If law enforcement has taken control of the situation prior to sample collection, they may require the collection of an additional sample set to be analyzed by their designated lab.
- Photographs and videos can be taken during the site characterization for use in the criminal investigation. Law enforcement should be consulted for proper handling during and after taking photographs/videos to ensure integrity of the evidence.

Maintaining crime scene integrity during site characterization is largely an awareness issue. If the site characterization team integrates the guidelines outlined above into their on-site activities, they will go a long way towards maintaining the integrity of the crime scene. It is also recommended that the WUERM and site characterization team lead coordinate with law enforcement, as part of emergency response planning, regarding appropriate procedures for activities performed at the site of a potential contamination incident.

4 Site Characterization Protocol

This section presents guidance and procedures for conducting site characterization activities. The site characterization protocol is divided into five stages, which are described in the following subsections and summarized below:

- Section 4.1, Customizing the Site Characterization Plan: Review the initial threat evaluation, review and customize the generic site characterization plan, identify the investigation site, conduct a preliminary hazard assessment, develop a sampling approach, and form the site characterization team.
- Section 4.2, Approaching the Site: Establish the site zone, conduct field safety screening, and observe site conditions.
- Section 4.3, Characterizing the Site: Repeat field safety screening, conduct the detailed site evaluation, and perform rapid field testing of the water.
- Section 4.4, Collecting Samples: Fill sample containers, preserve samples if necessary, and initiate chain of custody.
- Section 4.5, Exiting the Site: Perform final site check, remove all equipment and samples from the site, and re-secure the location.

Documentation of the site characterization activities and findings is an ongoing effort throughout each phase and result in a site characterization report as described in Section 5.

4.1 Customizing the Site Characterization Plan

The first stage of the site characterization process is the customization of the generic plan developed as part of planning and preparation for responding to contamination threats (Section 3.3). In general, the incident commander (most likely the WUERM) will develop the customized plan in conjunction with the site characterization team leader. The steps involved in the development of the plan include: 1) perform an initial evaluation of information about the threat; 2) identify one or more investigation sites; an assessment of potential site hazards; 3) develop a sampling approach; and 4) assemble a site characterization team. Each of these steps is discussed in the following section, followed by three examples that demonstrate customization of the site characterization plan. A template for the development of a site characterization plan is provided in Appendix 8.1.

4.1.1 Initial Evaluation

Figure 3-1 indicates that an initial evaluation of a contamination threat, followed by a determination that the threat is 'possible' may lead to site characterization activities. The information used to support the initial threat evaluation (see Module 2, Sections 3.1 and 3.2) is essential to the development of a customized site characterization plan. The initial evaluation should include a review of all available information from the threat warning as well as details about the suspected contamination site. The WUERM and site characterization team leader should review any alarms and security video that may be available from the area of the investigation site, as well as any on-line water quality monitoring data collected in the vicinity of the site. Much of this information should be summarized in the "Threat Evaluation Worksheet" in Module 2, Appendix 8.2.

4.1.2 Identification of Investigation Site

In order to proceed with site characterization activities, it is necessary to identify one or more investigation sites. This may be relatively straightforward or fairly complex depending on the circumstances of the threat. Factors to consider when selecting an investigation site include:

- Whether or not the physical location of suspected contaminant introduction is known.
- Whether or not the affected area was isolated from the rest of the system in time to contain the potentially contaminated water.
- Whether or not baseline monitoring/sampling is necessary (as discussed in Section 3.4).

If a suspected contamination site can be identified, it will likely be designated as the primary investigation site. Examples in which a suspected contamination site would be apparent include a security breach at a specific facility, a witness account of tampering at a particular location, or a verbal/written threat in which the site of contaminant introduction is named.

In the case of a threat warning in which a specific location is not evident, another approach must be taken to select investigation sites. Under this scenario, vulnerable sites, as identified in a utility's *vulnerability assessment*, might be considered as potential investigation sites. However, it may be more prudent to forgo a complete site characterization at an arbitrarily selected site, and instead increase the number of locations and frequency of sampling for water quality parameters routinely monitored and which have established baselines. Other approaches might involve increased monitoring of consumer complaints regarding unusual tastes or odors and/or working with local public health officials to identify unusual cases of disease that may be related to contaminated water. These latter approaches are intended to provide additional information to help determine whether or not the threat is 'credible' in situations where it may not be possible to conduct a thorough site characterization at a meaningful investigation site.

Some activities performed during site characterization depend only on the physical location of the site, such as the evaluation of site conditions and physical evidence. However, selection of sites for rapid field testing and water sampling must consider the potential spread of the contaminant in order to produce meaningful results. If the suspected contamination site is quickly isolated following the discovery of a contamination threat, the potential spread of the contaminant may be minimized, emphasizing the importance of rapidly initiating *immediate operational response* actions (Module 2, Section 3.3.2). If isolation is not possible or cannot assure that the suspect water has been contained to well defined area, then the potential spread of the contaminant should be considered when selecting secondary investigation sites (i.e., investigation sites other than the suspected contamination site).

Secondary investigation sites are selected to characterize the spread of a contaminant through a distribution system, which is a function of:
The suspected location of contaminant introduction.

- The elapsed time between contaminant introduction and water sampling/testing.
- The hydraulic operation of the system during this time period.
- The amount and purity of contaminant introduced.
- Fate and transport processes that might impact the contaminant concentration.

To rigorously address all of these factors when predicting the spread of a contaminant would be a lengthy and complex process in almost any situation. Furthermore, it is unlikely that the time of possible contaminant introduction will be known with a great degree of certainty, unless the tampering incident was directly observed, recorded, or triggered an alarm at a known time. Also, unless the identity of the contaminant is known and its properties well characterized, there will be insufficient information to predict the impact of various fate and transport processes on the concentration of the contaminant.

However, it may be possible to develop a rough estimate of the spread of a contaminant that will be sufficient for the purpose of selecting secondary investigation sites. To develop such an estimate, it will typically be necessary to assume both a location and time of contaminant introduction. As discussed previously, a potential contamination site may be evident from the threat warning, while the time of contaminant introduction will likely be unknown. However, it may be possible to bracket the time of the suspected contamination incident between the last time the site was visited and the time the threat was discovered. Once a location and time have been selected, the spread of the suspected contaminant can be estimated based on the hydraulics of the system.

Two approaches for estimating the spread of a suspected contaminant through a water system are: 1) application of operational knowledge of the system, and 2) application of a hydraulic model of the distribution system. The first approach requires knowledge of pressure zones and typical flow patterns through a distribution system, as well as information derived from SCADA, to estimate the spread of a possible contaminant slug through a system. The second approach involves the use of hydraulic models such as EPA Net, PipelineNet, MWHSoft, Stoner, and Haestad, among others. While this latter approach is more rigorous, these models are sophisticated and require a certain level of skill and a significant amount of time to run; thus, it may not be practical to use such models for the purpose of identifying investigation sites. Furthermore, the first approach may be sufficient for identifying secondary investigation sites for field testing and water sampling.

It is generally assumed that the identity and amount of contaminant introduced into the system will be unknown. In this case, the effect of fate and transport processes on the contaminant might be assumed negligible (i.e., the contaminant is not diluted or degraded), which would produce a conservative estimate of the contaminant concentration in the system. One could also assume an initial concentration of "100%" at the point of contaminant introduction, which would allow the fractional concentration to be tracked through the system as the contaminant is diluted.

Finally, if the contaminant is suspected to have spread through a portion of the system, it may be desirable to identify investigation sites for the purpose of baseline sampling. The analysis described above to estimate the spread of a suspected contaminant through a distribution system might also support the selection of investigation sites for baseline sampling. However, these sites should be **outside** of the potentially contaminated area. Other factors that may impact the baseline, as described in Section 3.4, should also be considered during the selection of secondary investigation sites for baseline sampling.

In all cases, it is critically important to identify investigation sites promptly so that site characterization activities can begin shortly after discovery of a contamination threat. The objective of site characterization is to gather information quickly in order to evaluate whether or not a threat is 'credible.' As discussed in Module 2, it is important to make this credibility determination in a relatively short period of time (**the target time period is less than eight hours from the time the threat warning is received**) such that response actions to protect public health can be implemented if necessary.

4.1.3 Site Hazard Assessment

During the development of a customized site characterization plan, an initial assessment of potential site hazards should be performed. Four hazard categories are considered in the context of site characterization:

1) Low hazard – no obvious signs of radiological, chemical, or biological contaminants are present at the site (i.e., in air or on surfaces). Contaminants that may be present in the water are assumed to be dilute and confined to the water.
2) Radiological – presence of radiological isotopes or emitters tentatively identified at the site or in the water (i.e., through the use of a field radiation detector).
3) Chemical – presence of highly toxic chemicals (e.g., chemical weapons or biotoxins) or volatile toxic industrial chemicals tentatively identified at the site or in the water, with a potential risk of exposure through dermal or inhalation routes.
4) Biological – presence of pathogens tentatively identified at the site, with a potential risk of exposure through dermal or inhalation routes.

The site hazard assessment is integral to the site characterization process and is intended to **minimize the risk to the site characterization team**. Figure 3-2 illustrates how information from site characterization activities may be used to refine the hazard assessment, which in turn may dictate the course of the site characterization. This figure also illustrates the importance of communication between the site characterization team and the incident commander during the course of on-site activities.

At the planning stage, the only information available to perform a site hazard assessment will be from the initial threat evaluation, as discussed in Section 4.1.1. The forms in the appendix to Module 2 that are designed to collect information to support the threat evaluation can also be used to support the initial site hazard assessment. Given the limited amount of information at this stage, it may only be possible to determine whether the site presents a low or high hazard. A 'low hazard' site would have no obvious signs of contaminants present in the environment (air and surfaces), while conditions at a 'high hazard' site would indicate a potential risk to personnel at the site. If the site is initially characterized as a low hazard, the standard safety procedures discussed in Section 3.1 should provide adequate protection to the site characterization team. On the other hand, if the site is characterized as a high hazard, HazMat responders with training and PPE appropriate for the site conditions should be contacted to provide support for site characterization activities.

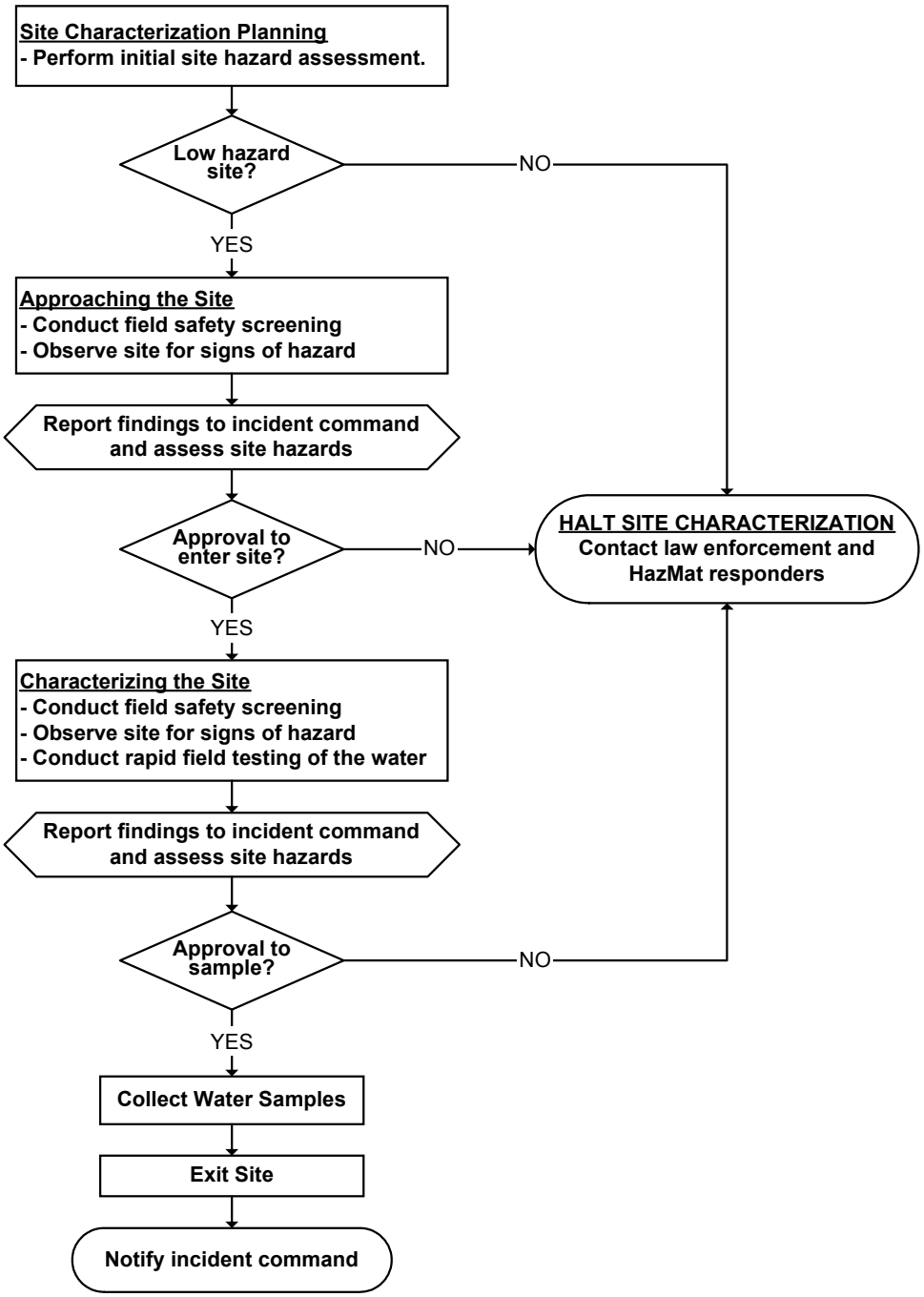


Figure 3-2. Integration of Site Hazard Assessment into Site Characterization Process

During the approach to the site, the team will perform field safety screening and observe the site for potential hazards **from the site perimeter** (see Section 4.2). At a minimum, field safety screening for radiation is recommended since it is a straightforward means of eliminating potential radiation hazards. Detection of excessive levels of radiation would result in the site being categorized as a radiological hazard. If expanded field safety screening techniques are employed, chemical and biological hazards might be tentatively identified at the site. For

example, a VOC sniffer might detect certain chemical hazards in the air. While field safety screening is a useful tool, it is just as important to carefully observe the site for potential signs of hazard, as discussed in Section 4.2.3. Due to the limited capability of even the most advanced field safety screening, site observations may be the most reliable indicator of potential hazards.

Upon completion of field safety screening and initial observation of site conditions, the site characterization team leader should report the findings to the incident commander, who will make a decision regarding whether or not it is safe for the team to enter the site. If there are indicators of a potential hazard, then incident command will likely halt the site characterization activities and contact law enforcement, and potentially HazMat, for assistance. In the absence of such indicators, the incident commander may clear the team to proceed further into the site.

Once at the investigation site, the team will commence their detailed site characterization including additional field safety screening, observation of potential site hazards, and rapid field testing of the water. The results of these activities are reported to the incident commander who will use this information to revise the site hazard assessment. If the incident commander determines that the site poses an unacceptable risk to the team, they may be instructed to retreat from the site. If there was the potential for personnel to become contaminated, they may need to retreat to the site perimeter and remain there until additional help arrives. If the site is still categorized as a low hazard, the incident commander may clear the team to proceed with sampling and complete the characterization. If the site is characterized as a chemical, biological, or radiological hazard, special sampling precautions may be necessary, as discussed in Section 4.1.4.

Upon exiting the site, the team leader should notify the incident commander to verify that everyone is safe and accounted for, that all necessary samples have been collected and secured, equipment has been collected, and the site has been secured. Outstanding or unresolved issues at this point should be communicated.

4.1.4 Sampling Approach

The objective of sampling from a suspected contamination site, or secondary investigation site, is to obtain and preserve a sample of the water at a particular time and location, so that it can be analyzed later if necessary. In order to perform sampling effectively, sampling requirements should be considered in the development of the customized site characterization plan. Factors to consider during the development of a sampling approach include:

- Which contaminants or contaminant classes will be sampled?
- What type of samples will be collected (i.e., grab or composite)?
- When and where will samples be collected?
- Are any special precautions necessary during sample collection?

The “Site Characterization Plan Template” in Appendix 8.1 includes a section for documenting the sampling requirements. It is important to consider that the initial sampling approach documented in the plan may need to be revised based on the findings of site characterization activities, as discussed later in this section.

Selection of target contaminants during development of a customized site characterization plan will be based on an initial assessment of information about the threat. Prior to site characterization, it is likely that little will be known about the identity of suspected water contaminants. In this case, the sampling approach may need to be comprehensive and include all analytes covered by the sample kit (see Table 3-2). In some cases, the available information about the threat may indicate the presence of a particular contaminant or contaminant class, and the sample plan may be adjusted accordingly. However, during this initial stage of site characterization, it may still be prudent to plan to collect a complete sample set (i.e., all sample containers in the utility's emergency water sampling kit) from the investigation site.

The two most common types of environmental samples are *grab samples* and *composite samples*. A grab sample is a single sample collected at a particular time and place that represents the composition of the water only at that time and location. The sample is collected all at once and at one particular point in the sample medium. A composite sample is composed of several specific aliquot collected at various sample locations and/or different points in time, which are then combined to form one composite sample. Analysis of a composite sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value.

In general, it is recommended that only grab samples be collected from distribution systems; however, in some situations it may be necessary to composite samples over time or position. An example of a scenario in which it may be necessary to collect composite samples is sampling conducted to characterize a large reservoir where collection and analysis of a large number of discrete samples may be time and cost prohibitive. One disadvantage of composite samples is that they may dilute concentrations of contaminants that would otherwise be detected in discrete grab samples. Another disadvantage is that if a contaminant is detected, it is impossible to know which specific individual sample was the source of the contaminant.

The time and location of sample collection will be addressed by the selection of investigation sites, as discussed in Section 4.1.2. Due to the potential spread of a suspected contaminant through a distribution system, sampling may be performed at secondary investigation sites rather than the primary site.

The need for special precautions during sample collection will likely be determined by the site hazard assessment described in thee previous section. Figure 3-3 illustrates four sampling approaches based on the hazard categories defined in Section 4.1.3. Prior to the initiation of site characterization activities, there may be limited information available to determine which sampling approach is appropriate. However, the results of the site evaluation and field testing may allow for a more precise characterization of the hazards at the site, and thus provide a basis for refining the sampling approach. For example, the site evaluation may indicate the presence of a hazardous chemical (e.g., unexplained dead animals at the site), which may indicate that precautions are necessary during sample collection for chemicals, as shown in Figure 3-3.

Under low hazard conditions, no special sampling techniques are necessary beyond good safety practices as described in Section 3.1. Under this scenario, samples for chemical and pathogen analysis are collected according to the procedures described in Section 4.4.

If the site is characterized as a radiological hazard due to the detection of excessive levels of radioactivity during field safety screening, samples should be collected for radiological analysis by personnel trained and equipped to work at radioactive contamination sites (e.g., Superfund teams). Figure 3-3 also suggests the collection of a large volume water sample using the 10-liter containers listed in Table 3-1, in case it is necessary to perform analyses for additional contaminants following radiological analysis. The large volume water samples should only be handled by the trained responders and stored in appropriate facilities that would minimize the risk of potential exposure to radiation.

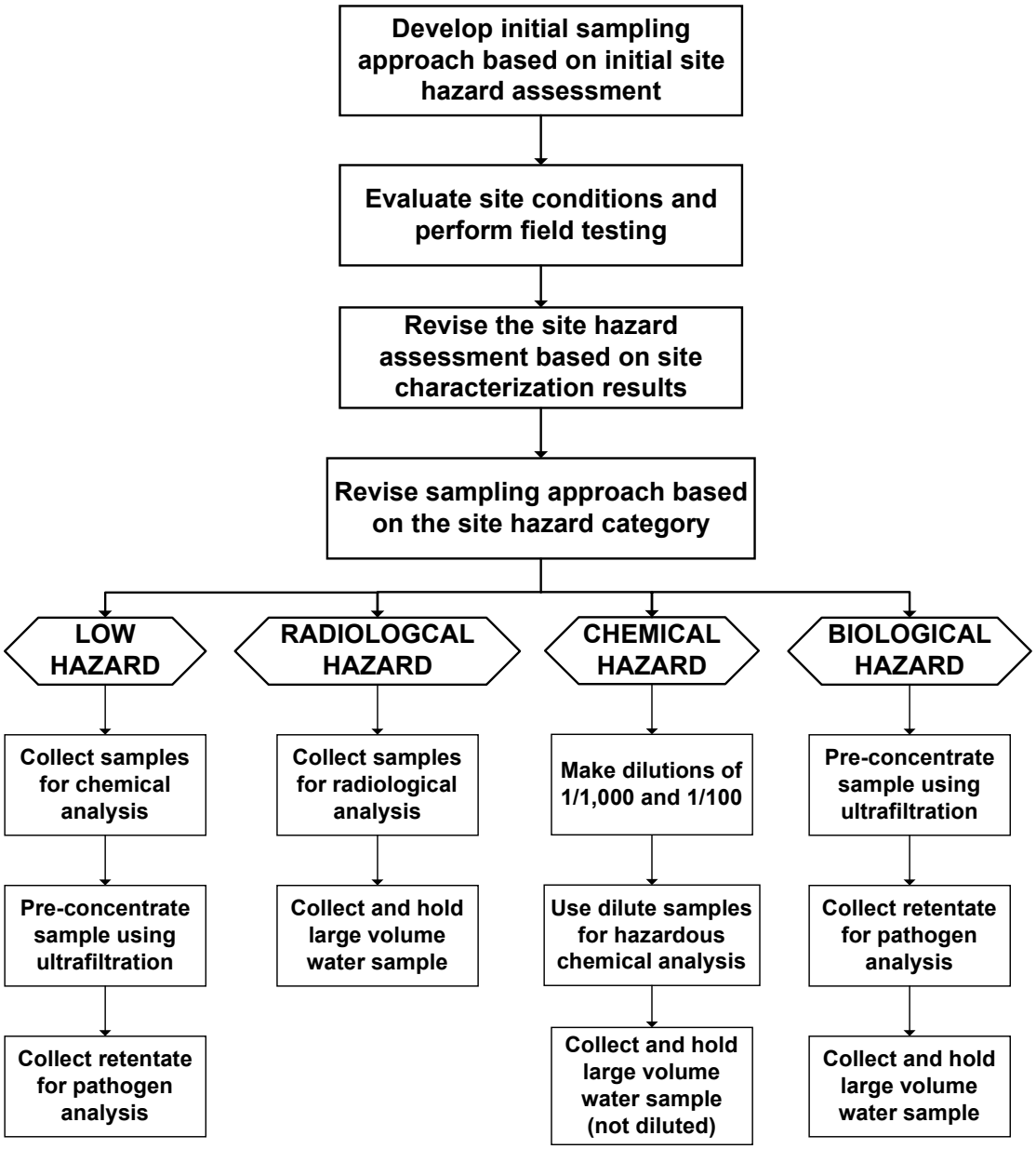


Figure 3-3. Integration of Site Hazard Assessment into the Sampling Approach

If the site is characterized as a chemical hazard, dilution of samples collected for chemical analysis may be an appropriate sampling strategy to reduce the risk during sample transport and analysis. **Dilution does not reduce the risk to personnel collecting the sample since they are working with the undiluted water; thus site procedures appropriate for a chemical hazard should still be followed.** Dilutions of 1/1,000 and 1/100 are appropriate for chemical hazards already present in water (a 1/10,000 would only be appropriate for concentrated material). The most dilute sample (i.e., 1/1,000 dilution) should be delivered to the laboratory for analysis first. The remaining diluted samples should be stored in a safe and secure location and delivered to the laboratory if the result from the analysis of the 1/1,000 dilution turns up nothing unusual. In addition to the diluted samples, it is suggested that a large volume water sample (not diluted) be collected in case it is necessary to perform analyses for additional contaminants following analysis of the diluted samples. The large volume water samples should only be handled by trained responders and stored in appropriate facilities that would minimize the risk of potential exposure to hazardous chemicals.

If the site is characterized as a biological hazard, pathogen sampling should be conducted according to the procedures described in Section 4.4.3. Figure 3-3 also suggests the collection of a large volume water sample in case it is necessary to perform analyses for additional contaminants following pathogen analysis. Another potential strategy for sampling for chemicals from the site of a biological hazard, which is not shown in Figure 3-3, is the use of UV irradiation to inactivate pathogens in the processed sample. UV irradiation will inactivate a majority of the suspected pathogenic organisms and provide a degree of protection for the analysts. **UV irradiation does not reduce the risk to personnel collecting the sample since they are working with the non-irradiated water; thus site procedures appropriate for a biological hazard should still be followed.** Irradiation of the sample can be most effectively accomplished through the use of a flow-through UV irradiation device, but may also be performed in batch mode, although the latter is likely to be less effective or require more time to achieve the desired results. Note that the dose required for the inactivation of most biological agents has not been fully characterized, nor has the effect of UV irradiation on all chemicals of concern. Thus, it is generally recommended that a large volume sample be collected for possible chemical analysis, as shown in Figure 3-3, rather than employing UV irradiation. The large volume water samples should only be handled by the trained responders and stored in appropriate facilities that would minimize the risk of potential exposure to biological hazards.

4.1.5 Formation of a Site Characterization Team

The site characterization team will be responsible for performing the site investigation, field safety screening, rapid field testing, and sampling collection. The makeup of the team may for a specific site characterization activity will depend on the results of the initial site hazard assessment, as discussed in Section 4.1.3. If the site is characterized as anything other than a low hazard, a HazMat response team should be contacted to support site characterization activities. The HazMat responders may ‘clear’ the site for entry by utility personnel or may perform the actual site characterization. Under low hazard conditions, utility personnel may be able to perform site characterization activities if they receive training in basic safety practices and use of any specialized equipment.

For safety reasons, the team should include at least two people, with one person in constant communication with incident command. One member of the team should have experience/knowledge of security investigations, including the analysis of security breaches (e.g., vandalism, opportunistic break-ins) and basic procedures for maintaining the integrity of a crime scene. The other team member should have experience in water quality, sampling, and use of field test equipment. Additional team members may be added as appropriate for a given situation (e.g., an individual from the utility's operations department may be included to support decisions regarding containment of the suspect water). All members of the site characterization team should be capable of performing a critical evaluation of site conditions and documenting the findings from site characterization activities.

4.1.6 Examples of Site Characterization Plan Customization

The customized site characterization plan developed before the team is sent to the site may be very similar to the generic plan due to the limited amount of information that will be available at this initial stage. Customization of the plan may actually occur in the field as the team begins to gather information. In particular, the field testing and sampling activities may need to be revised based on the initial observations at the site. The plan should be revised through collaboration between the incident commander (most likely the WUERM) and site characterization team leader.

The following three examples are intended to illustrate how a customized site characterization plan might evolve from the point that the threat warning is discovered through the conduct of site characterization activities. In these examples, it is assumed that a generalized plan has been developed with the following elements:

- **Sample kits** developed according to the example presented in Table 3-1 and including all of the sample containers listed in Table 3-2. The kit contains a 'Field Guide' with the forms in the appendix to this module, simple SOPs, and other supporting documentation.
- **A field test kit** developed according to the example of the core field test kit presented in Table 3-3, including: a radiation meter, a pH/conductivity probe, a chlorine residual test kit, and a cyanide test kit.
- **A utility site characterization team**, consisting of a security specialist and a water quality specialist, has been formed and trained in basic safety procedures, use of field testing equipment, and use of basic PPE (i.e., the PPE listed in Table 3-1).
- **A communication plan** to keep the WUERM informed during all stages of site characterization.

Example 1: A threat warning is received in the form of an alarm trigger on an access hatch to a distribution system storage reservoir. The operator immediately informs the WUERM, and actions are quickly taken to hydraulically isolate the tank from the system. This immediate operational response is determined to be effective for preventing the water in the tank from spreading to the rest of the system.

The WUERM and site characterization team leader immediately begin to customize the site characterization plan. While there is very limited information about the threat, the suspected contamination site is obvious from the threat warning. Thus, the storage tank is designated as the

primary investigation site. There is insufficient information to characterize the potential site hazards; however, the decision is made to treat this as a low hazard site until evidence is collected to indicate otherwise. The reason for this decision is that false alarm triggers do occur with some frequency, and to date, none have presented hazardous conditions. Furthermore, safeties are built into the site characterization process that are designed to minimize the risk to the site characterization team.

At this point, there is insufficient information to further customize the site characterization plan. A decision is made to dispatch the utility site characterization team to the investigation site, equipped with the standard field test kit and two sample kits. The plan will be reevaluated following the site characterization team's initial observations of the site.

Upon arrival at the location of the tank, the team establishes a perimeter at a safe distance from the tank to perform their initial evaluation. From the perimeter, the site characterization team conducts field safety screening using the radiation meter and observes that levels are well below a predetermined trigger level. Their initial observations indicate that the hatch is open, but no other signs of potential hazard are evident. The team leader contacts the WUERM using a two-way radio and reports their initial findings. The WUERM clears the team to proceed with site characterization activities.

At the perimeter, the team dons the PPE in the sample kit and cautiously approaches the site. They observe that the lock on the access hatch is missing, but no other individuals are in the area and there is no obvious evidence of contamination at the site. The team continues the characterization and conducts rapid field testing of the water for pH, conductivity, chlorine residual, and cyanide. The water quality parameters all appear normal, and the results of the cyanide test are negative. The team leader contacts the WUERM to report the results of the site characterization and discuss the need for any modification to the site characterization plan at this point. The sense is that the threat is not 'credible,' but it is decided to collect one set of samples that will be stored at the utility laboratory in case there is a need to analyze the samples later.

The team collects the samples, completes the documentation of the site characterization, and prepares to exit the site. Before leaving, the team places a new lock on the hatch and secures the site (this is important to avoid future false alarms). Upon leaving the site, the team leader contacts the WUERM to report that the team has completed its investigation and is in transit to the utility laboratory to deliver the samples for storage.

Commentary. In this example, customization of the site characterization plan only involved the identification of the suspected contamination site and an initial assessment that the site probably did not pose a significant hazard. The evaluation that the site did not pose a significant hazard was based on previous incidents and the experience of the WUERM. During site characterization, there were no signs of hazard or contamination; thus a decision was made to collect a single set of samples and not pursue any additional site characterization activities at this time. These samples were taken as a precaution and will only be sent to a laboratory for analysis if it is later determined to be necessary. The WUERM may continue the threat evaluation following the completion of these site characterization activities, since other information may be relevant to the evaluation

regarding whether or not the threat is 'credible' (see Module 2). Furthermore, the decision to return the tank to normal operation will be based on the outcome of the threat evaluation, not solely on the results of the site characterization. Of course the site characterization provides important information to support the threat evaluation process.

Example 2: A threat warning is received in the form of security breach discovered at a water distribution system tank by a utility crew. Furthermore, evidence at the site indicates that material may have been introduced into the tank. The WUERM is immediately notified and asks the operational staff to review the SCADA data and inspection records for this tank. This evaluation indicates that 48 hours have elapsed between the time the breach was discovered and the most recent inspection that found the site secured, and that the storage tank was feeding the distribution system for at least 12 hours during that period, but it is not known whether or not this occurred before or after the security breach.

The WUERM and site characterization team leader immediately begin to customize the site characterization plan. Since the tank is the site of suspected contamination, it is designated as the primary investigation site. However, due to the potential spread of the suspected contaminant into the distribution system, secondary investigation sites are designated in the distribution system. These secondary sites are selected using operational knowledge of the system, as discussed in Section 4.1.2. Eight secondary sites are selected in the area impacted by the potentially contaminated water, and an additional eight sites are selected outside of this area for the purpose of baseline monitoring. At each investigation site, the standard set of field tests will be conducted and a complete set of samples will be collected. However, only the primary site (i.e., the location of the tank) will undergo a full investigation.

Due to the circumstances of the threat warning, the WUERM notifies utility management, law enforcement, and HazMat. This is in accordance with procedures outlined in the utility's *emergency response plan* (ERP). The incident commander (which may or may not be the WUERM in this case) determines that the secondary sites can be characterized by utility sampling crews trained in the site characterization procedures. HazMat will characterize the primary site due to the presence of suspicious material at the site, but the utility site characterization team leader will support the HazMat team on issues related to water quality and sampling.

The HazMat team takes command of the primary investigation site and implements their procedures for field safety screening and characterizing any potentially hazardous materials at the site, in particular residual materials found in a container. The HazMat team does not detect any hazards during their safety screen, although they do find a suspicious material at the site that is collected for subsequent analysis. At this point, the utility site characterization team leader is cleared to enter the site and provides guidance to the HazMat responders as they perform field testing of the water and collect water samples.

The results of limited rapid field testing performed at all investigation sites showed no obvious signs of contamination; however, there was evidence of potential contamination at the storage tank (i.e., the suspicious material in the container). Based on the collective information and

results of the threat evaluation, a decision is made to immediately deliver all samples to the laboratory for analysis.

Commentary. In this example, the site characterization plan was complicated by the fact that there was the potential for potentially contaminated water to enter the distribution system. The plan addressed this by identifying additional sites for field testing and sampling in the distribution system. Secondary sites were selected to look for indicators of contamination in the potentially contaminated area as well as to characterize baseline levels outside of this area. This is particularly important for the non-specific field tests included in the kit, which require comparison to a baseline to effectively interpret the results.

This example also involves a situation in which the discovery of the threat warning yielded information about potential site hazards and evidence of contamination. This information influenced both the threat evaluation as well as the site characterization plan. Implicit in this example is the decision that the threat had some level of initial credibility such that it was necessary to contact law enforcement and HazMat. This in turn impacted the makeup of the site characterization team.

Example 3. A citizen observes a suspicious looking individual hurriedly leaving the fenced area surrounding a distribution system storage tank. The concerned citizen calls 911, but the police do not arrive in time to apprehend the suspect. The responding officer notices that the lock was cut from the perimeter fence and the access hatch was left open. The officer calls dispatch and requests that the water utility be contacted immediately. The WUERM is notified and immediately contacts operations to determine whether or not the storage tank can be isolated. Within an hour, the tank is physically isolated from the rest of the distribution system.

The WUERM and site characterization team leader immediately begin to customize the site characterization plan. As the potential site of contamination, the storage tank is designated as the primary investigation site. It is unclear whether or not the tank was isolated quickly enough to prevent the spread of water into the system; however, for the initial plan it is decided that only the primary site will be characterized. Since no indicators of potential hazard were observed by law enforcement, it is decided to treat this as a low hazard site until evidence is collected to indicate otherwise.

At this point there is insufficient information to customize the site characterization plan further. A decision is made to dispatch the utility site characterization team to the investigation site equipped with the standard field test kit and two sample kits. In addition to the standard field test kit, the team also takes a field detector that the utility recently purchased to expand their capabilities. While some basic testing has been done with the new detector, there has been insufficient time to perform much baseline monitoring or a rigorous performance evaluation.

Upon arrival at the location of the tank, the team establishes a perimeter at a safe distance from the tank to perform their initial assessment. From the perimeter, the site characterization team conducts field safety screening using the radiation detector and observes that levels are well below a predetermined trigger level. There initial observations indicate that the hatch is open, but no other signs of potential hazard are evident. The team leader contacts the WUERM using a

two-way radio and reports their initial findings. The WUERM clears the team to proceed with site characterization activities.

At the perimeter, the team dons the PPE in the sample kit and cautiously approaches the site. They observe that the lock on the access hatch is missing, but no other individuals are in the area and there is no obvious evidence of contamination at the site. The team continues the characterization and conducts rapid field testing of the water for pH, conductivity, chlorine residual, and cyanide. The water quality parameters all appear normal and the results of the cyanide test are negative. However, the new detector used for expanded field testing yields a positive result for a contaminant of concern. The team leader contacts the WUERM to report the results of the site characterization, particularly the tentative identification of the contaminant. The WUERM and site characterization team leader realize that this tentative result will need to be confirmed through laboratory analysis, and revise the site characterization plan based on this result.

The operations staff believes that the tank was isolated in time to contain any contaminated water, but since they don't know how long the suspect was at the tank, they cannot be certain. Based on this information, the plan is modified as follows. Two complete sample sets will be collected from the tank and prepared for immediate delivery to the laboratory. In parallel with this activity, two additional utility sampling teams will be sent out to several locations within two specific areas of the distribution system. One team is sent to an area of the distribution system that normally receives water from the suspect tank to evaluate whether or not the contaminant has spread. The other team is sent to an area of system that is hydraulically isolated from the area served by the storage tank in order to conduct baseline sampling. Both teams are equipped with several complete sample kits. They are instructed to conduct expanded field testing at several locations within their assigned areas, and if they observe a positive result, to collect two complete sample sets. Each team is instructed to collect at least one complete sample set from within their target area, even if all field test results are negative.

Commentary. This example illustrates how the results of site characterization, particularly field testing, may be used to revise the site characterization plan in the field. Given the eyewitness account of the intrusion and the positive field test results, this may be considered a 'credible' threat, and additional response measures may be appropriate (see Module 2). However, interpretation of the expanded field test results is complicated by the fact that this technology is relatively new to the utility and there is insufficient baseline data to support interpretation of the results. While expanded field testing can be a valuable tool during site characterization, it is important to evaluate the technology and characterize the baseline **before** the technology is used during an actual site characterization.

Like the previous case, this example illustrates how the potential spread of the contaminant can complicate the selection of investigation sites. The solution in this case was to use the expanded field testing for the purpose of identifying additional sites for sample collection, as well as collecting additional data on the tentatively identified contaminant. The revised plan also specified the collection of at least one set of samples in each zone, which is prudent since the performance of the expanded field test has not been well characterized.

4.2 Approaching the Site

Once the site characterization plan has been customized to a particular situation, the site characterization team will be dispatched to the investigation site. The next stage of the process is the approach to the site, which is primarily intended to ensure that conditions are safe for the team to proceed with the characterization. This stage will also provide information to refine the site hazard assessment, as discussed in Section 4.1.3. During the approach to the site, site zones are established, field safety screening is conducted, and the conditions at the site are observed. These steps are described in this section.

4.2.1 Establish Site Zones

The site area should be defined and secured If the site hazard assessment indicates a potential radiological, chemical, or biological hazard, HazMat officials will likely establish a *protective action zone*. This is the zone where specialized PPE is required and may be further defined by HazMat officials per hazardous materials emergency response guidelines. The boundary of the protective action zone is referred to as the *site perimeter*.

A *staging area* may be established at the site perimeter to control entrance and exit of personnel and perform operations such as personnel and equipment decontamination. If the situation is deemed hazardous, the staging area should be located **far outside** of the protective action zone, and upwind from the investigation site, in an area that does not require specialized PPE. Security, law enforcement, or the fire department can secure the area and can help control traffic into and out of the area. The WUERM should be notified of any site zones that are established at the site of a suspected contamination incident, even if the WUERM is not the incident commander.

4.2.2 Field Safety Screening

The goal of field safety screening is to screen the site for potential hazards to determine if additional safety precautions are necessary as site characterization activities proceed. Field safety screening is conducted using a field test kit (see Section 3.2.2) and involves an evaluation of the environment at the site (i.e., in air and on surfaces). Field safety screening begins at the site perimeter with screening for excessive levels of radioactivity in the vicinity. Expanded field safety screening may be conducted for other hazards, such as volatile chemicals, chemical weapons, and biological contaminants. However, such equipment should only be used by individuals trained in its use, and the performance of the equipment should be validated.

The results of field safety screening should be immediately reported to the incident commander who will instruct the team whether or not to proceed with the site characterization. The results of field safety screening should be documented using a form such as the "Field Testing Results Form" included in Appendix 8.3.

4.2.3 Initial Observation of Site Conditions

Assuming that permission to proceed with site characterization has been granted, the site characterization team should cautiously approach the site, from upwind if possible. The team

should begin the investigation by looking for signs that unauthorized individuals might still be at the site. Potential signs of the presence of intruders include visual observation of individuals, unexplained vehicles at the site, voices or other noises coming from the site, or unexplained equipment or materials left at the site. If it is suspected that intruders may still be present, the site characterization team should retreat to a safe location and immediately contact law enforcement. If the team can do so safely, they may want to maintain visual contact with the site until law enforcement arrives (i.e., to observe the activities of the unauthorized individual(s) at the site).

It is recommended that only one member approach the site while the other remains on the perimeter maintaining visual and verbal contact at all times. The person on the perimeter should maintain contact with the incident commander to be able to call for assistance if necessary. The team member approaching the site should continue to perform field safety screening and observe the site for potential hazards as he/she approaches the site. If any signs or evidence indicate hazardous conditions, the team should exit the site, immediately notify the incident commander, and return to the vehicle and remain there until assistance arrives. It is important **not** to leave the site completely since decontamination of personnel and equipment may be necessary. Once the team member approaching the site has completed an initial observation of site conditions and determined that it is safe, the other team member can proceed into the site.

While approaching the site, all team members should look for indicators of contamination. These include general evidence of contamination as well as signs specific to the presence of chemical contaminants.

General evidence of contamination, including chemical, biological, and radiological material, may include:

- Discarded PPE such as gloves, masks, goggles, and protective outerwear.
- Discarded equipment such as tubing, hoses, pumps, sprayers, lab equipment, etc.
- Empty containers unusual for the site (i.e., not litter or other items typically discarded in the area). Be aware of containers with labels for biohazards, radiological hazards, or chemical hazards.
- Unexplained or unusual residual material around the site, such as powders, granules, oily liquids, and metallic debris. Such residual material should be considered a potential hazard and should only be handled or sampled by properly equipped HazMat responders.
- Unexplained or unusual water conditions, such as oily films, foaming, or discoloration.

Signs specific to the presence of chemical contamination include:

- Evidence of dead/dying/sick animals, beyond normal carrion (e.g., road kill).
- Numerous dead insects in a localized area that are not a result of a local pest control program (e.g., spraying for mosquitoes).
- Isolated areas at the site where vegetation (bushes, lawns, trees, shrubs, food crops, weeds), are dead, discolored, or withered (assuming no drought conditions).
- Numerous oily liquid droplets on surfaces or an oily film on the water surface.
- Unusual odors, such as those listed in Table 3-4. It is important to consider whether the particular odor is unexpected or unusual for the surrounding area.

- A low-lying fog that is not explained by current weather conditions.

If any of these obvious signs of chemical contamination are evident, the team should return to their vehicle at a safe distance from the site until additional help arrives and immediately contact incident command. It is important not to retreat beyond the site perimeter since personnel may inadvertently spread a contaminant if they are not properly decontaminated before completely exiting the site.

Specific signs of radiological and biological contamination are less obvious than those associated with chemical contamination; however, the general evidence of contamination listed above still applies. The lack of obvious signs of radiological contamination underscores the importance of including field testing for elevated levels of radioactivity. While there may be no reliable indicators specific to biological contamination, a disinfectant residual can offer protection against many pathogens, thus field testing for disinfectant residual is recommended (see Section 4.3.2).

Table 3-4. Characteristics of Example Chemical Contaminants[1]

Chemical	Physical State	Odor	Color
Aldicarb	Solid or powder	Sulfur	
Chloropicrin	Oily liquid	Sharp and irritating	Colorless
Cyanide	Solid or powder	Bitter almonds	
Dicrotophos	Liquid	Ester	Yellow-brown
Lewisite	Liquid	Geraniums	
Mustard	Liquid	Garlic	
Oxamyl	Crystalline solid	Sulfur	White
Phorate	Liquid	Skunky	Colorless
Sarin	Liquid	Fruity	Colorless
Soman	Liquid	Fruity	Colorless
TEPP	Liquid	Fruity	Yellow
VX	Oily liquid	Sulfur	Colorless

1: These are characteristics of the concentrated chemical and may not be evident if diluted in water.

At this stage, it is critical to rapidly relay information to incident command, thus the team should stay in constant communication with the incident commander and report the findings of the initial site evaluation immediately. The observations made during the approach to the site should be documented using a form such as the "Site Characterization Report Form" included in Appendix 8.2.

4.3 Characterizing the Site

Following approval to enter the site, the team will begin the detailed site characterization process. The purpose of this stage of the process is to continue activities to evaluate potential risks to the team and collect information that will inform the threat evaluation process. During this stage, the team will evaluate site conditions and conduct rapid field testing of the water, as discussed in the following section.

4.3.1 Evaluation of Site Conditions

Upon entry to the investigation site, the team should continue field safety screening. Verbal results should be communicated to the incident commander, and permission to proceed should be obtained once the team has arrived at the actual site.

The team should continue to evaluate the site for indicators of contamination as discussed in Section 4.2.3 and document additional findings using the form in Appendix 8.2. Potential indicators of contamination or other hazards should be verbally reported to the incident commander immediately. If included in the sample kit, a camera and/or video camera can be used to photograph any unusual conditions or findings to assist in the documentation of site conditions. If the site is considered hazardous, or a crime scene, special handling of the equipment and film development will be necessary.

If there are any obvious signs of contamination at the site, the team should return to their vehicle at a safe distance from the site until additional help arrives and immediately contact incident command. It is important not to retreat beyond the site perimeter since personnel may inadvertently spread a contaminant if they are not properly decontaminated before completely exiting the site.

4.3.2 Rapid Field Testing

There are three objectives of field testing the water: 1) To provide additional information to assess the credibility of the threat; 2) To tentatively identify contaminants that would need to be confirmed by laboratory testing; and 3) To determine if hazards tentatively identified in the water require special precautions during sampling. Furthermore, the field test results will support the site hazard assessment process described in Section 4.1.3. Because these results are important for both the threat evaluation and site hazard assessment, they should immediately be reported to the incident commander. Results of rapid field testing of the water can be documented using the "Field Testing Results Form" included in Appendix 8.3.

The field test kit presented in Table 3.3 identifies a core set of rapid field tests for water, which includes chlorine residual, pH, and cyanide (it may also be possible to test the water for radioactivity depending on the probe). Table 3.3 also presents several options for expanded rapid field testing of the water. The decision to include any expanded field testing capability should be made during general planning for site characterization activities. As discussed in Section 3.2.2, any field detectors or kits planned for use during site characterization should be evaluated and characterized with respect to performance, and a baseline established for the monitored parameter.

Use of detectors or equipment that have not been characterized during an emergency may lead to greater uncertainty with respect to how to respond. For example, how would one respond to a positive result from an anthrax test kit without knowledge of the rate of false positive results or information regarding typical background levels?

Field test results should be evaluated in the context of the performance characteristics of the test and should generally be considered tentative until confirmed through some other definitive means. For example, a negative result may not indicate the absence of a contaminant if the field test has a high rate of false negative results or is not sufficiently sensitive to detect the contaminant at levels of concern. Likewise, positive results might be due to interferences or may represent contaminants other than the target. Thus, positive results should generally be confirmed through laboratory analysis. While it is important to consider these limitations, the information provided by field test results can be valuable in making decisions early in the response to a contamination threat, particularly during the transition from the 'possible' to the 'credible' stage, as discussed in Module 2. Results from rapid field testing of the water can also be used to refine the sampling plan, as discussed in Section 4.1.4.

4.4 Collecting Samples

Following field safety screening and rapid field testing, the site characterization team will collect samples for possible laboratory analysis. At this stage of the site characterization, sample collection may be viewed as a precautionary measure to capture the water quality at the location and time of sample collection. If the threat is determined to be 'credible,' then samples may be shipped to the laboratory for analysis, as shown in Figure 3-1. If not, the samples should be held until the investigation is closed.

This section provides general procedures for sampling, as well as procedures specific to chemical and biological sampling. In addition to the guidance presented in this module, EPA and USGS have developed sampling guidance for other purposes that may be relevant to emergency water sampling. Some useful links to additional sampling guidance include:

- A series of standard operating procedures published by EPA's Environmental Response Team at http://www.ertresponse.org/Response_Resrcs/index.htm.
- Training developed for EPA on scene coordinators at http://www.epaosc.org/training.htm.
- USGS field procedures for water sampling at http://water.usgs.gov/owq/Fieldprocedures.html.

4.4.1 General Sampling Procedures

The following general guidelines are applicable to sampling for both chemicals and pathogens, while specific sampling procedures for these two contaminant classes are provided in Sections 4.4.2 and 4.4.3, respectively.

These guidelines are applicable to the collection of samples from investigation sites within the distribution system, including storage tanks, pressurized pipes, and other distribution system elements. In most cases, samples will be collected from a tap connected to the distribution system element. However, it may be necessary to collect samples from a large body of water, such as a finished water reservoir. Sampling from such large bodies of water, whether finished or source water, requires different sampling techniques than those used to sample from distribution systems. Guidance developed for the collection of samples from surface water sources, such as the EPA Environmental Response Team's standard operation procedure #2013,

may also be applicable to sampling from large finished water reservoirs (http://www.ertresponse.com/sops/2013-r10.pdf).

General Water Sampling Guidelines

1) Review the site characterization plan prior to sampling to ensure that all samples are collected.
2) Each sample container should be properly labeled using a waterproof marker with the following information: analysis, preservative (if any), dechlorinating agent (if any), sample location, sample identification, sample collection date and time, and sampler's initials. Additional information requested on the sample label should be provided as well.
3) To minimize the time spent on the site during the sample collection stage, it is recommended that sample labels for each container be completed before beginning sample collection.
4) Check for the presence of any in-line filters (e.g., home treatment devices) that might interfere with sampling. Remove such devices if present.
5) Flush sample taps for a time sufficient to displace the water in connecting lines in order to obtain a representative sample from distribution system element of interest.
   a) Keep the flow rate from the sample tap sufficiently low in order to avoid splashing and aerosolizing water droplets. Divert water to a drain if possible.
   b) If the water flushed from the tap might pose a hazard to the discharge area, it may need to be collected for decontamination.
6) Critical information for each sample should be documented:
   a) The same information captured on the sample labels should be transferred to a sample documentation form to serve as a sample inventory (see Appendix 8.4 for an example form).
   b) Sample custody should be closely tracked and documented using a chain of custody form (see Appendix 8.5 for an example form).
7) Samples may be considered evidence, and thus should be subject to appropriate security measures:
   a) Samples should be under the control of designated personnel at all times.
   b) When samples are not in the possession of designated personnel, they should be secured (e.g., locked in a *secure area*) and only accessible by designated personnel. In the field, samples may need to be locked in a vehicle.
   c) Chain of custody should be initiated immediately after sample collection.
   d) If necessary, duplicate samples can be collected for law enforcement.
   e) If necessary, take photographs of the samples at the site of collection as another form of sample documentation.
8) If the decision is made to analyze the samples immediately, the laboratory should be contacted as soon as possible so they can prepare for arrival of the samples.
9) If the decision is made to hold samples rather than send them to the laboratory for immediate analysis, the following precautions should be taken:
   a) Samples should be chilled, but protected from freezing.
   b) Samples should be held until the threat evaluation has been completed and the decision has been made to either analyze the samples or close the investigation.
   c) The shortest holding time for a particular analysis will dictate the maximum time that samples should be held prior to analysis. Holding times for preserved samples are contained in their respective analytical methods (see Module 4), and are typically 7-28

days for properly preserved samples, although the respective analytical method should be consulted for details about holding samples. If it is necessary to store unpreserved samples, the stability of the target analyte in water should be considered when determining how long an unpreserved sample might be stored.

It is important to follow any special laboratory requirements regarding sample collection and transport since this may affect the quality of the analytical results. For example, some procedures or laboratories may require analysis of special QC samples such as field duplicates, field blanks, trip blanks, and field matrix spikes. There may also be specific chain of custody, notification, and shipping requirements. Arrangements should be made with a laboratory prior to an incident so that samplers are aware of, and can prepare for, any special requirements.

It may also be advisable to collect backup samples in case there is a problem with the set that is delivered to the laboratory, or if there is a need for additional samples for confirmation or analysis by another entity (e.g., a specialty laboratory or law enforcement). Backup samples should be properly stored, secured, and tracked such that the integrity of the samples is maintained. While collection of individual backup samples may be appropriate in some cases, it may be logistically simpler to collect a large volume sample in a 10-liter container as a backup.

4.4.2 Chemical Sampling Procedures

The following procedures are appropriate for collecting samples for chemical analysis from drinking water distribution systems. If samples need to be collected from a large body of water without a suitable sample tap, the surface water sampling guidelines referenced in Section 4.4.1 may be used. If the samples are considered to be hazardous, it may be necessary to implement certain hazardous materials sampling techniques, as discussed in Section 4.1.4, in addition to the guidelines presented below.

General Water Sampling Procedures for Chemical Contaminants

1. Carefully fill sample containers with water flowing from the sample tap. Avoid splashing or aerosolizing water droplets during sample collection. Do not use rubber or plastic tubing for the collection of samples for chemical analysis
2. Do not rinse or overfill the sample containers. This is especially important if the sample container contains a preservative or dechlorinating agent.
3. If necessary, add any preservatives and/or dechlorinating agents. Preservatives and/or dechlorinating agents may be added to the sample containers during sample kit preparation, which can significantly decrease the complexity and time required for sample collection. (See note on preparation of pre-preserved sample containers in Section 3.2.1.)
4. If necessary, adjust the pH of the sample per method instructions.
5. When sealing sample containers that have open top caps and septa, make certain that the Teflon side (smooth side) is facing towards the water.
6. VOC samples should be collected with no headspace.
7. For containers with closed top caps (pesticides, etc.) attempt to fill the container to the top leaving very little or no headspace.
8. Wipe the outside of the sealed containers with an antiseptic wipe or a mild bleach solution if deemed necessary.

9. If the sample container is not pre-labeled, place a label on the container and complete the requested information. Transfer the information on the sample label to the sample documentation form (Appendix 8.4).
10. Attach a custody seal to the individual sample container, if required by the organization responsible for sample collection and handling. In some cases, it may be sufficient to place the custody seal on the shipping container rather than the individual sample containers themselves. Record the information on chain of custody record (Appendix 8.5).
11. Place the sample container into a sealable plastic bag (bubble wrap baggies can provide protection against breakage of glass sample containers).
12. Place the sealed plastic bags containing the samples into an appropriate, rigid shipping container and pack with frozen ice packs (preferred) or sealable freezer bags filled with ice. If ice is used, the bag should be thoroughly sealed to avoid leakage. See Section 6 for more details on sample packaging and shipment.

4.4.3 Microbiological Sampling Procedures

Sampling for microbiological contaminants is closely coupled to the analytical approach for pathogens as discussed in Module 4, Section 8. In particular, there are two general approaches to pathogen sampling and analysis that depend on whether or not a pathogen has been tentatively identified, as illustrated in Figure 3-4.

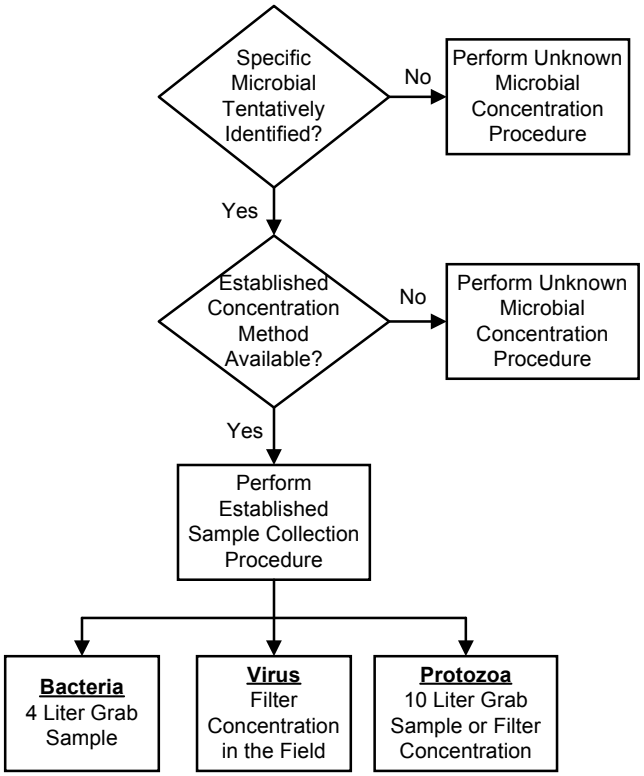


Figure 3-4. Sampling Approach for Microbial Contaminants

If the microbiological contaminant has been tentatively identified **and** has an established analytical technique suitable for water, then samples should be collected in accordance with that technique. However, established and validated sample collection and analytical techniques for microbial contaminants in water are limited to a few pathogenic microorganisms, principally enteric bacteria, viruses and protozoa, and a few other organisms with known waterborne transmission. Module 4, Section 8.2 provides additional information on those pathogens with established analytical techniques. Figure 3-4 indicates the following sampling approach for bacteria, virus, and protozoa:

- **Bacteria**: collect a four-liter grab sample for membrane filtration and culture of several different types of bacteria through use of selective media.
- **Virus**: filter between 100 and 1,200 liters of water through a positively charged filter (ICR Microbial Laboratory Manual, EPA/600/R-95/178, April 1996, http://www.epa.gov/nerlcwww/). The processed filters can be shipped to the laboratory or viruses adsorbed to the filter can be eluted in the field and shipped as a one-liter *retentate* (or concentrate) to a laboratory for further processing by conventional procedures.
- **Protozoa**: collect a 10-liter grab sample for shipment to a laboratory where it is filtered to concentrate the protozoa for subsequent processing and analysis (Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration by IMS/FA, EPA-821-R-99-006, April 1999, http://www.epa.gov/nerlcwww/). Another alternative is to perform the filtration in the field, similar to the approach for virus.

Many microbiological methods also specify the addition of a dechlorinating agent in order to maintain the viability of the organisms so that they can be cultured. The established method for the target microbiological contaminant should be consulted to determine the appropriate dechlorination and preservation techniques.

If the microbial contaminant is unknown, sample collection is performed through the use of ultrafiltration, which is a membrane filtration process that retains particles, including microorganisms, larger than the molecular weight cut-off (MWCO) of the membrane. The solution containing the concentrated particles and pathogens is called the retentate, while the water that passes through the ultrafiltration membrane is called the *filtrate*. Ultrafiltration can concentrate viruses, bacteria, spores, and parasites if the MWCO is sufficiently small. Thus, the method is suitable for sampling water with an unknown microbiological contaminant.

There are several reasons for using the ultrafiltration sampling approach rather than sampling for one or more specific pathogens using existing, standardized methods. First, the sample may contain a mixture of microbial contaminants; thus use of methods for specific pathogens may miss other pathogens that are present. Second, due to the low oral infectious dose of most waterborne pathogens, a sample of 100 liters of finished water may need to be concentrated to obtain a suitable level of sensitivity. Third, sample concentration methods for viruses and protozoa require separate field equipment and procedures and are practical only if the microbial contaminant is suspected or identified as one amenable for concentration by each of these specific technologies. Thus, it may be necessary to utilize a more general sample concentration procedure based on ultrafiltration since it targets a wider range of microorganisms.

In general, the ultrafiltration procedure involves the concentration of a large (100 liters or more) volume of water using an ultrafiltration field concentration apparatus, such as that shown in Figure 3-5. The basic elements of this apparatus include an input reservoir for sample collection, a peristaltic pump, a cross-flow hollow fiber membrane cartridge, a retentate reservoir and a filtrate reservoir. Operating the unit in cross-flow mode is preferable because the high velocity of water scours the membrane surface, preventing excessive deposition of material on the surface. Non-reactive membranes are preferable such as polysulfone or low protein binding membranes.

Sample filtration is conducted by recirculating water (necessary to maintain cross-flow conditions) with a 5-10 psi differential between the feed and filtrate pressure. The pressure differential forces water through the hollow fiber membrane, while particles and microorganisms are concentrated in the retentate. The volume of the retentate is reduced to approximately 250 mL by recirculating the concentrated sample through the smaller retentate loop for capture in the retentate reservoir. The retentate reservoir vessel can be used for sample shipping if necessary. The sample retentate can also be recovered by backflushing (reversing the flow through of the hollow fiber membrane cartridge). Research is currently underway to refine the design of the ultrafiltration apparatus, and future versions of this module will provide more detail on its design and operation.

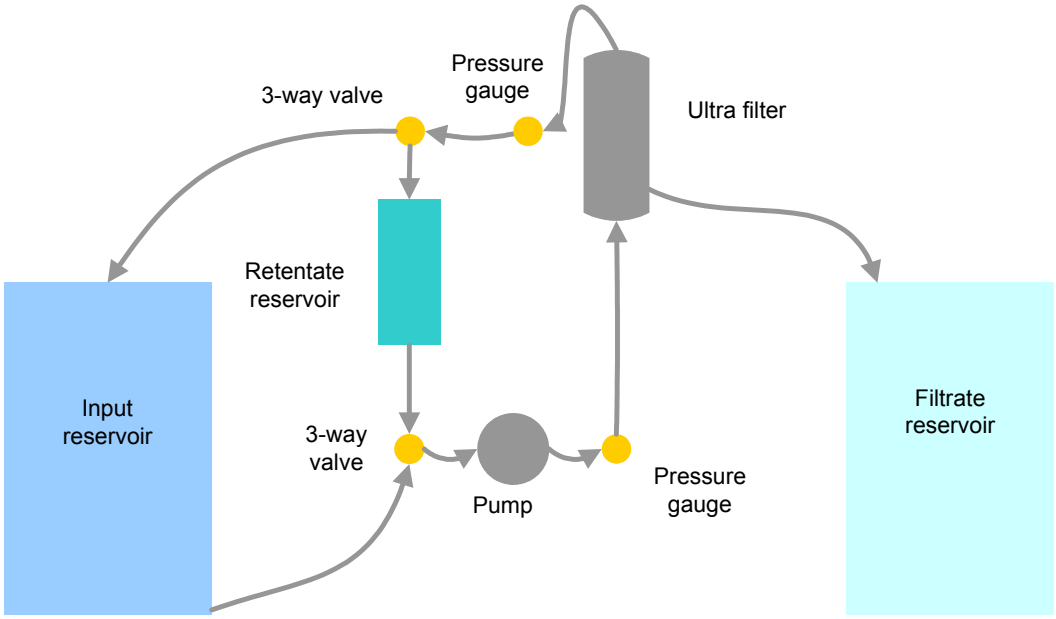


Figure 3-5. Ultrafiltration Field Concentration Apparatus

Some of the general water sampling procedures listed for chemicals also apply to sampling for pathogens, as listed below.

General Water Sampling Procedures for Microbiological Contaminants

1. Avoid splashing or aerosolizing water droplets during sample collection or field concentration.
2. Do not rinse or overfill the sample containers. This is especially important if the sample container contains a preservative or dechlorinating agent.
3. Any sample aliquot collected for culture analysis should be handled in a manner such that viability of the microorganisms is maintained.
4. If necessary, add any preservatives and/or dechlorinating agents. Preservatives and/or dechlorinating agents may be added to the sample containers during sample kit preparation, which can significantly decrease the complexity and time required for sample collection. (See note on preparation of pre-preserved sample containers in Section 3.2.1.)
5. Wipe the outside of the sealed containers with an aseptic wipe or a mild bleach solution.
6. If the sample container is not pre-labeled, place a label on the container and complete the requested information. Transfer the information on the sample label to the sample documentation form (Appendix 8.4).
7. Attach custody seal to the individual sample container, if required by the organization responsible for sample collection and handling. In some cases, it may be sufficient to place the custody seal on the shipping container rather than the individual sample containers themselves. Record the information on chain of custody record (Appendix 8.5).
8. Place the sample container into a sealable plastic bag (bubble wrap baggies can provide protection against breakage of glass sample containers).
9. Additional instructions for packaging samples potentially containing infectious biological contaminants are provided in Section 6.
10. Place the sealed plastic bags containing the samples into an appropriate, rigid shipping container and pack with frozen ice packs (preferred) or sealable freezer bags filled with ice. If ice is used, the bag should be thoroughly sealed to avoid leakage. See Section 6 for more details on sample packaging and shipment.

4.5 Exiting the Site

For a site characterized as a low hazard, it should not be necessary to implement extensive procedures for exiting the site. The following general precautions are recommended when exiting a low hazard site:

- Verify that any hatches, locks, etc., are properly secured before leaving the site.
- Collect all samples, equipment, and materials and move them to the site perimeter. Anything brought onto the site should be removed from the site.
- Make sure that all samples are in the cooler(s) along with ice packs and that the cooler is sealed with chain of custody tape, if applicable.
- Remove all PPE at the site perimeter, and place disposable PPE, along with any other garbage, into the heavy-duty plastic trash bag. Close the bag securely.
- Place all equipment, samples, and the sealed plastic trash bag into the vehicle.
- If the site has perimeter security (e.g., a fence and gate), verify that the perimeter has been properly secured before leaving the site.
- Ensure that all forms have been completely filled out before leaving the site.

If the site was categorized at a higher hazard level and/or if the site is considered a crime scene, then special procedures for exiting the site will likely be required by HazMat officials or law enforcement. For example, personnel and equipment may be required to undergo decontamination prior to exiting the site, and access to the site is likely to be tightly controlled. If the site is considered a crime scene, the site may be secured by law enforcement, and qualified investigators will be responsible for collecting any physical evidence from the site (such as empty containers, dead animals, etc.). A detailed discussion of site exit procedures required under these conditions is beyond the scope of this document, and will likely vary depending on the organization responsible for incident command and site characterization.

5 Site Characterization Report

In order to provide useful information to support the threat evaluation process and the development of an analytical approach, the findings of the site characterization should be summarized in a report. This report is not intended to be a formal document, but simply a concise summary of information from the site activities that can be quickly assembled within an hour or two. The recommended content of the report includes:

- General information about the site.
- Information about potential site hazards.
- Summary of observations from the site evaluation.
- Field safety screening results, including any appropriate caveats on the results.
- Rapid field water testing results, including any appropriate caveats on the results.
- Inventory of samples collected, and the sites from which they were collected.
- Any other pertinent information developed during the site characterization.

The "Site Characterization Report Form" (Appendix 8.2), "Field Testing Results Form" (Appendix 8.3), and "Sample Documentation Form" (Appendix 8.4) are designed to record most of this information during site characterization activities, and these completed forms may serve as the core of the site characterization report. If multiple investigation sites were characterized in response to a particular threat, the results from all site characterization activities should be assembled into a single report.

The information contained in the site characterization report will likely be used to support several follow-on activities:

- Hazard assessment of the site.
- Threat evaluation.
- Implementation of precautionary actions to protect public health.
- Estimate of the spread of the contaminant.
- Analytical plan (including the decision regarding whether or not to analyze samples).

These activities lead into the latter phases of the response to a contamination threat, which are discussed in other modules of the "Response Protocol Toolbox."

The site hazard assessment should be completed at the conclusion of site characterization activities; thus, it may only be necessary to document the conclusions of the assessment in the report. This provides the incident commander with an overall understanding of the site hazard conditions and provides the opportunity to revise the assessment, if necessary.

Following site characterization, a significant amount of new information should be available to support the threat evaluation initiated at the time threat warning is received (see Module 2). Thus, the threat evaluation should be revised following review of the results from the site characterization. In many cases, these results will be critical to the determination regarding whether or not the contamination threat is 'credible.' This determination should be documented in the "Threat Evaluation Worksheet" included in Module 2, Appendix 8.2. This revised worksheet should be included at the front of the site characterization report since it represents the outcome of the site characterization activities.

The revised threat evaluation will dictate the next steps in the response process (sample analysis, public health response, and remediation/recovery). If the threat is determined to be 'not credible' following site characterization, then the investigation may be closed and the system returned to normal operation. On the other hand, if the threat is deemed 'credible' at this stage, it may be necessary to take steps to protect public health as the response progresses. This may require an estimate of the spread of the suspected contaminant through the system, and the site characterization results may support such an analysis (particularly if multiple investigation sites were characterized).

If a decision is made to analyze the samples collected from the site in an attempt to 'confirm' a contamination incident, it will be necessary to develop an analytical approach. The site characterization report can serve as a valuable resource when developing the analytical approach; thus it is critical that the laboratory and other parties involved in designing the analytical plan have immediate access to the report. A briefing among relevant parties is recommended in order to transition from site characterization to laboratory analysis. The development of an analytical approach, and the link between site characterization and sample analysis, is described in Module 4, Section 5.

Finally, it is important to maintain records of all site characterization activities, even for incidents that were ultimately dismissed as 'not credible.' Good records management practices are important since documentation about a particular activity might need to be accessed later, long after the details of the incident have faded from memory. Furthermore, by maintaining documentation about all threat warnings that occur at a utility, a historic record can be established that may help in evaluating future threats. Such a record is considered as a potential information resource in the threat evaluation process (see Module 2, Section 4.1.2).

6 Sample Packaging and Transport

In order to perform analysis of samples beyond rapid field testing, it will be necessary to properly package the samples for transport to the appropriate laboratories as quickly as possible. Prompt and proper packaging and transport of samples will:

- Protect the integrity of samples from changes in composition or concentration caused by bacterial growth or degradation that might occur at increased temperatures.
- Reduce the chance of leaking or breaking of sample containers that would result in loss of sample volume, loss of sample integrity, and potential exposure of personnel to hazardous substances.
- Help ensure compliance with shipping regulations.

Sampling packaging and transport is governed by a number of regulations, as administered by the International Air Transport Association (IATA, http://www.iata.org/) and the U.S. Department of Transportation (DOT, http://www.dot.gov/). In addition, there may be additional requirements specified by states, local authorities, and/or shipping companies. The regulations and requirements that govern the packaging and transport of samples will depend on the nature of the material in the samples. The pertinent regulations are largely based on whether the samples are classified as a hazardous material. Hazardous material is defined as any substance that appears in the 49 CFR Hazardous Materials Table (http://hazmat.dot.gov/rules.htm), subject to certain exemptions based on the quantity and concentration of material.

For the purpose of this module, two general classes of samples are considered: environmental samples and hazardous samples. Environmental samples are those collected from environmental media, such as natural or treated waters, that are not expected to be contaminated with hazardous materials at concentrations that would pose a risk to unprotected personnel. The vast majority of water samples collected are expected to be classified as environmental samples.

Hazardous samples typically consist of concentrated hazardous materials (as defined above), and they are typically collected from drums, tanks, lagoons, pits, waste piles, fresh spills, or areas previously identified as contaminated. Accordingly, they require special handling procedures due to their potential toxicity or hazard. The distinction between environmental samples and hazardous samples becomes blurred when hazardous materials might be present in an environmental sample at unknown concentrations.

The decision regarding the classification of a sample as environmental or hazardous may be based on the hazard classification of the site from which samples were collected. In Section 4.1.3, four broad site hazard categories are defined for the site of a suspected water contamination incident: low, radiological, hazardous chemical, and infectious biological agent.

Samples collected from a low hazard site may be considered environmental samples in most cases. By contrast, samples collected from sites categorized as a radiological, chemical, or biological hazard may be classified as potentially hazardous materials. However, the use of certain sample collection techniques, such as dilution and UV irradiation (as discussed in Section 4.1.4), may reduce the hazard and allow samples to be considered environmental. Following is

some general information regarding packaging and transport of low hazard (environmental) and high hazard samples.

6.1 Low Hazard Samples

6.1.1 Packaging

The sampling procedures in Section 4.4 end with the sample being placed into a prepared cooler. Cooler preparation is an important part of packaging, and it is imperative that samples are correctly and carefully packed in shipping containers to prevent the sample containers from breaking or leaking. Following are steps in preparing a cooler:

1. Use a clean cooler to prevent cross contamination. Seal all drain holes of the cooler, both inside and out, to prevent leakage in the event of a compromised sample container.
2. Check all lids/caps to make sure they are tightly sealed and will not leak.
3. Seal samples within a clear plastic bag.
4. If possible, fully chill samples to 4°C or less prior to placement within suitable packing materials.
5. For additional protection in case of breakage, the cooler may be lined with non-combustible, absorbent packing material such as rock wool, ground corncobs, perlite, or clay-based absorbents (e.g., kitty litter or 'oil dry ').
6. After the samples are placed in the cooler, conduct an inventory of the contents of the shipping cooler against the corresponding sample inventory and chain of custody records.
7. Cover samples in double-bagged ice, or frozen ice packs, to prevent water damage to packing materials. **Do not** pour loose ice directly into the sample cooler. The bagged ice will maintain the temperature of the samples within the shipping cooler.
8. A temperature blank may be included within each cooler being shipped. The temperature blank may be a 40 mL vial filled with water and labeled "temperature blank." There are also "memory" thermometers and other data-logging devices available for this purpose.
9. Include necessary paperwork (copies of sample documentation and chain of custody forms) in the cooler. It may be convenient to place all of this in a plastic bag or pouch and affix it to the underside of the lid of the cooler. The original documentation should be maintained by the utility.
10. After the contents of the cooler have been checked for completeness, all openings of the cooler should be sealed with tape. Correct chain of custody seals, if required, should be attached to the cooler in a manner such that it would be apparent if the cooler has been opened prior to laboratory receipt.
11. Prepare the cooler appropriately for shipping depending on the way the container is to be transported.
12. Clearly label the cooler with the address of the laboratory where the samples are to be sent.

6.1.2 Transport

In some cases, it may be desirable to have the site characterization team transport the samples directly to the laboratory. During sample transport, it is important that the team take steps to

maintain sample integrity and chain of custody. Maintaining sample integrity may involve delivering the samples to the laboratory as soon as possible, without making any unnecessary stops. Lengthy, unnecessary stops may allow time for the samples to degrade, even when the samples are chilled, reducing the quality of the results. Coolers also have limited insulation value, so if a cooler is left in a warm vehicle while the driver performs errands, the samples could heat up, potentially degrading some sample components. In addition, leaving the sample unattended may violate chain of custody procedures, which must be observed at all times. If it is necessary to hand over control of the cooler to another responsible party, this transfer should be noted on the chain of custody form.

While the site investigation team would typically deliver samples by ground transportation, some transport may be accomplished by air, i.e., airplanes or helicopters. In this case, those responsible for sample transport should consider the effects of their flight patterns on integrity of the samples. For instance, sudden changes in air pressure might cause some previously sealed containers to burst or vent.

In other cases, the only option may be to use an overnight shipping company to deliver the samples to the laboratory. Many shipping companies currently do not have special requirements for shipment of environmental water samples in coolers, other than leak prevention. If overnight shipping is to be used, the site characterization team should have ready access to all pertinent information about the shipping company, including: name, phone number, hours of operation, shipping schedule, any special shipping requirements, and pick-up/drop-off requirements. There is a block for this information in the "Site Characterization Plan Template" in Appendix 8.1. Chain of custody is also important when using an overnight shipping service. Shipping records should be maintained as part of documenting chain of custody. Most major companies are able to maintain chain of custody upon sample receipt, although this should be verified.

6.2 High Hazard Samples

In general, HazMat teams will likely have packaging and shipping procedures for high hazard samples that might contain radiological, chemical, or biological contaminants. It is important to verify that local HazMat teams that might assist in site characterization activities do have the procedures and capabilities in place to transport hazardous samples. A brief overview of considerations for shipment of high hazard samples is provided below.

6.2.1 Packing

Hazardous materials shipments must be packaged in compliance with sections 173.24 and 173.24a of 49 CFR (http://hazmat.dot.gov/rules.htm). Often this is accomplished by the use of United Nations Performance Oriented Package. In 49 CFR, hazardous materials are divided into nine classes, which refer mostly to concentrated materials. Relevant classes for high hazard water samples include Class 2.3 (poisonous gases), Class 6.1 (poisonous materials, inhalation hazard), Class 6.2 (infectious substance), and Class 7 (radioactive substances).

Radiological Hazards. Packaging of radioactive materials is regulated under CFR 49 173.401-173.476 as a Class 7 material. In general, for Class 7 materials the package may consist of one

or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, devices for cooling or absorbing mechanical shocks, and service equipment for filling, emptying, venting and pressure relief. The conveyance, tie-down system, and auxiliary equipment may sometimes be designated as part of the packaging. The type of packaging is dependent on the nature of the radioactive hazard (specific radionuclide and amount of radioactivity). Trained hazardous materials responders should select of the most appropriate packaging for a specific radioactive hazard.

Chemical Hazards. Chemical hazards may be broken down into chemical warfare agents, biotoxins, and conventional toxic chemicals (e.g., cyanide, pesticides, industrial chemicals, etc.). Packaging requirements for chemical hazards are similar to those for low hazard chemicals except that special care is necessary to prevent release of the contaminated water, as might occur through water leaks or volatilization. Preventing such release may involve providing multiple layers of containment, and a regular cooler by itself might not offer appropriate protection. Placing the sample inside an approved shipping container, which in turn is placed inside the cooler, may satisfy the packaging requirement. Some approved shipping containers include a temperature control system (i.e., freezer packs), so the cooler may not be necessary. Approved containers that meet regulatory requirements are readily available since hazardous materials are packaged and shipped routinely in a number of industries. There may be volume or weight limits to the quantity of water that may be packaged in an approved container, largely due to limitations in the structural integrity of the container.

Transport of hazardous materials requires proper labeling and declaration of hazards. This labeling and declaration may be necessary even if a commercial shipper is not used. For instance, if samples are transported to the laboratory by vehicle, it is important that the content, and potential hazards, of the packages by clearly documented to facilitate proper safety and handling precautions during transfer of sample custody.

A special situation exists for chemical weapons. Following collection, the samples must be placed under a tent for a set period of time and the tent monitored for the potential release of chemical weapon vapors using a suitable detector. If chemical weapons are suspected, law enforcement should be contacted as they will have access to expertise and procedures for safely packaging and transporting these types of samples.

Biological Hazards. Packing requirements and procedures for biological samples have been developed by the CDC to facilitate safe shipment of the samples to LRN laboratories, which may be found at http://www.bt.cdc.gov/labissues/PackagingInfo.pdf. In summary, triple packaging (primary receptacle, water tight secondary packaging, and durable outer packaging) is required for infectious biological agents or materials that are known or suspected of containing them.

For biological hazards, the "Infectious Substance" label (shown at the web site listed above) must be placed on the outside of the package. This packaging must be certified to meet rigorous performance tests as outlined in the IATA, DOT, USPS, and PHS regulations. Detailed information about this packaging is found in “Biosafety in Microbiological and Biomedical Laboratories,” United States Department of Health and Human Services, 4th Ed., edited by J.Y.

Richmond and R.W. McKinney, U.S. Government Printing Office, 1999. This document is also available at: http://www.cdc.gov/od/ohs/biosfty/bmbl4/bmbl4s1.htm.

Currently, the largest available container size that meets the CDC shipping requirements is four liters; however, CDC is working on packaging designs to accommodate 10-liter samples. There are also specific requirements and guidance available for certain agents, such as anthrax, http://hazmat.dot.gov/guide_anthrax.htm, although the applicability of this guidance to water samples should be carefully considered.

6.2.2 Transport

Many of the same principles that apply to the transport of low hazard samples also apply to high hazard samples, assuming they are properly packaged and labeled. Depending on the nature of the hazard, law enforcement may be involved in the transport of hazardous samples, especially if the services of a specialty laboratory are required. For instance, if chemical weapons are suspected, a technical escort service from the military may take custody of the samples and transport them to a chemical weapons laboratory. Other technical escort services are available for a variety of samples, but this resource is limited and may be accessed only through specific channels, such as law enforcement.

Many commercial shipping companies (such as FedEx, UPS, USPS, etc) have varying policies regarding labeling and documentation, some based on regulatory requirements, for overnight shipping of hazardous materials.. Some companies offer free advice and training on packaging and shipping such samples. The site characterization team should be familiar with the regulatory requirements, as well as other shipping company policies. In general, commercial shipping companies may transport some many hazardous samples provided that packaging and declaration requirements are fulfilled. However, the shipper may not pick up potentially hazardous samples, but require that they be delivered to the shipping center.

Maintaining and documenting the chain of custody is important when using an overnight shipping service for both high hazard and low hazard samples. Shipping records should be maintained as part of documenting chain of custody, and it should be verified that the company can maintain chain of custody throughout the delivery process.

As part of planning activities, it is recommended that a potential shipping company be contacted with a request for their lists of allowable and prohibited hazardous materials. The prohibited materials often include substances within the following classes: Class 2.3 (poisonous gases), Class 6.1 (poisonous materials, inhalation hazard), Class 6.2 (infectious substances), and Class 7 (radioactive material II and III). Thus, many hazardous substances may be listed as prohibited materials by many commercial shipping company. For example, it is unlikely that a commercial shipper could transport a sample containing chemical warfare agents. However, exemptions to these policies may be available for some hazardous materials. For example, many infectious substances may be acceptable if packaged according to CDC guidelines, which were designed with shipping regulations in mind. Exemptions will vary from company to company.

7 References and Resources

References and information cited or used to develop this module are listed below. The URLs of several sources are cited throughout the text. These URLs were correct at the time of the preparation of this document. If the document is no longer available at the URL provided, please search the sponsoring organization's Web site or the World Wide Web for alternate sources. A copy of referenced documents may also be provided on the CD version of this module, although readers should consult the referenced URL for the latest version.

Chemical Hazards Response Information System (CHRIS). http://www.chrismanual.com

FBI Handbook of Forensic Services
http://www.fbi.gov/hq/lab/handbook/intro.htm

Hazardous Materials Guide for First Responders. http://www.usfa.fema.gov/fire-service/hmgfr3.cfm

Interagency Intelligence Committee on Terrorism (IICT). Chemical/Biological/Radiological Incident Handbook. October 1998. http://fas.org/irp/threat/cbw/CBR_hdbk.htm

National Institute of Justice. U.S. Department of Justice. An Introduction to Biological Agent Detection Equipment for Emergency First Responders, NIJ Guide 101-00. December 2001. http://www.ojp.usdoj.gov/nij/pubs-sum/190747.htm.

National Institute of Justice. U.S. Department of Justice. Guide for the Selection of Chemical Agent and Toxic Industrial Material Detection Equipment for Emergency First Responders, NIJ Guide 100-00. June 2000. http://www.ojp.usdoj.gov/nij/pubs-sum/184449.htm.

NIOSH Emergency Response Resources. http://www.cdc.gov/niosh/topics/emres/

OSHA, 2002, "Safety and Health Topics Personal Protective Equipment"
http://www.osha.gov/SLTC/personalprotectiveequipment/index.html

OSHA, 2003a, "OSHA e-HASP Software –Version 1.0, September 2003"
http://www.osha.gov/dts/osta/oshasoft/ehasp/

OSHA, 2003b, "Occupational Safety and Health Administration Homepage"
http://www.osha.gov

U.S. Army Soldier and Biological Chemical Command. Law Enforcement Officers Guide for Responding to Chemical Terrorist Incidents. January 2003.

Standard Emergency Management System (SEMS) Guidelines
http://www.oes.ca.gov/Operational/OESHome.nsf/Content/B4943535210895448825 6C2A0071E038?OpenDocument

U.S. Environmental Protection Agency. On Scene Coordinator homepage
http://www.epaosc.org

U.S. Environmental Protection Agency. On Scene Coordinator Training http://www.epaosc.org/training.htm.

U.S. Environmental Protection Agency. Chain of Custody guidelines http://www.epa.gov/safewater/certlab/laba.html

U.S. Environmental Protection Agency. Environmental Technology Verification program for field detection technologies. http://www.epa.gov/etv/

U.S. Environmental Protection Agency. Environmental Response Team. Standard Operating Procedures. http://www.ertresponse.org/Response_Resrcs/index.htm.

U.S. Environmental Protection Agency. Environmental Response Team. Health and Safety. http://www.ertresponse.com/health_safety/index.htm

U.S. Environmental Protection Agency. Environmental Response Team. General Field Sampling Guidelines Standard Operating Procedure (#2001). August 11, 1994. http://www.ertresponse.com/sops/2001.pdf.

U.S. Environmental Protection Agency. Environmental Response Team. Surface Water Sampling Standard Operating Procedures (#2013). January 17, 2002. http://www.ertresponse.com/sops/2013-r10.pdf

U.S. Environmental Protection Agency. ICR Microbial Laboratory Manual, EPA/600/R-95/178, April 1996, http://www.epa.gov/nerlcwww/

U.S. Environmental Protection Agency. Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration by IMS/FA, EPA-821-R-99-006, April 1999, http://www.epa.gov/nerlcwww/

U.S. Geological Survey. Field Procedures for Water Sampling http://water.usgs.gov/owq/Fieldprocedures.html.

8 Appendices

8.1 Site Characterization Plan Template

INSTRUCTIONS

This form is intended to support in the development of a customized site characterization plan developed in response to a specific water contamination threat. The incident commander and site characterization team leader should develop this plan jointly if possible. The completed form will be used to guide site characterization activities in the field; however, it may be necessary to revise the initial plan based on initial observations at the site. A form should be completed for each investigation site that will be characterized.

THREAT WARNING INFORMATION

Consult Module 2, Appendix 8.2 "Threat Evaluation Worksheet" for details about the threat.

INVESTIGATION SITE

Site Name: _____

Type of facility:

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank reservoir
- ☐ Elevated storage tank
- ☐ Finished water
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

INITIAL HAZARD ASSESSMENT

Are there any indicators of an explosive hazard? ☐ Yes ☐ No

If "Yes," notify law enforcement and do not send a team to the site.

Initial hazard categorization

- ☐ Low hazard
- ☐ Chemical hazard
- ☐ Radiological hazard
- ☐ Biological hazard

If the initial hazard assessment indicates a chemical, radiological, or biological hazard (as described in Module 3, Section 4.1.3), then only teams trained to deal with such hazards should be sent to the site.

SITE CHARACTERIZATION TEAM

Name & Affiliation of Site Characterization Team Leader:

_____

Drinking water utility staff:

- ☐ Water quality specialist Name: _____
- ☐ Security specialist Name: _____
- ☐ Operations specialist Name: _____
- ☐ Other _____ Name: _____

Representatives from other agencies:

- ☐ Local law enforcement ☐ Fire department ☐ HazMat
- ☐ US EPA ☐ FBI ☐ Other

COMMUNICATION PROCEDURES

Mode of communication:

- ☐ Phone ☐ 2-way radio ☐ Digital
- ☐ Facsimile ☐ Other _____

Reporting events:

- ☐ Upon arrival at site ☐ During approach ☐ Site entry
- ☐ After site evaluation ☐ After field testing ☐ Site exit
- ☐ Other _____

FIELD SCREENING CHECKLIST

✔	Parameter[1]	Screen[2]	Meter/Kit ID[3]	Check Date[4]	Reference Value[5]
	Radiation	Both			
	Chlorine residual	Water			
	pH / conductivity	Water			
	Cyanide	Water			
	Volatile chemicals	Safety			
	Chemical weapons	Both			
	Biotoxins	Water			
	Pathogens	Water			

1. List the parameters that will be evaluated as part of field screening (examples are listed).
2. Screening may be conducted for safety, rapid water testing, or both.
3. Report the unique identifier for the meter or kit used during screening.
4. Report date of last calibration, expiration date, or date of last equipment check as appropriate.

5. List any reference value that would trigger a particular action, such as exiting the site.

SAMPLING CHECKLIST

✔	Analyte[1]	No. Samples	Sample Preservation[2]
	Standard VOCs		
	Semi-volatiles		
	Quartenary nitrogen compounds		
	Cyanide		
	Carbamate pesticides		
	Metals/elements		
	Organometallic compounds		
	Cyanide		
	Radionuclides		
	Non-target VOCs		
	Non-target organic compounds		
	Non-target inorganic compounds		
	Immunoassays		
	Pathogens – culture		
	Pathogens – PCR		
	Water quality – bacteria		
	Water quality – chemistry		

1. List the parameters that will be sampled during site characterization (examples are listed).
2. List preservatives and dechlorinating agents and indicate if they are to be added in the field.

EQUIPMENT CHECKLIST

- ☐ Completed Site Characterization Plan
- ☐ Emergency Water Sampling Kit (Table 3-1)
- ☐ Reagents (if stored separately)
- ☐ Laboratory grade water (5 gal)
- ☐ Special equipment for the specific site
- ☐ Additional documentation
- ☐ Field Testing Kit (Table 3-3)
- ☐ Bags of ice or freezer packs
- ☐ Rinse water (20 liters)
- ☐ Disposable camera
- ☐ Other _____

SAMPLE HANDLING INSTRUCTIONS

Sample delivery:

- ☐ Return samples to water utility
- ☐ Ship samples to specified location
- ☐ Deliver samples to specified recipient (e.g., laboratory, law enforcement, shipping co., etc.)

Name of recipient: _____

Phone No.: _____ Fax No.: _____

Delivery address: _____

_____

Sample storage and security:

Describe any special precautions or instructions related to sample storage and security:

_____

_____

_____

SIGNOFF

Incident Commander (or designee responsible for developing Site Characterization Plan):

Print name _____

Signature _____ Date/Time: _____

Site Characterization Team Leader:

Print name _____

Signature _____ Date/Time: _____

8.2 Site Characterization Report Form

INSTRUCTIONS

Members of the site characterization team can use this form to record their observations at the investigation site. It also serves as a checklist for notifying incident command at key points during the characterization. Additional checklists are included in this form for sample collection and exiting the site. The completed form can also be used as a component of the site characterization report. A form should be completed for each investigation site that is characterized

GENERAL INFORMATION

Date: _____ **Time arrived investigation at site:** _____

Name of Site Characterization Team Leader: _____

Phone No.: _____ **Fax No.:** _____

LOCATION OF INVESTIGATION SITE

Site Name: _____

Type of facility:

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank reservoir
- ☐ Elevated storage tank
- ☐ Finished water
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Weather Conditions at Site: _____

_____

Additional Site Information: _____

_____

APPROACH TO SITE

Time of Approach to Site: _____

Initial Field Safety Screening (as listed in the "Site Characterization Plan"):

☐ None ☐ Radiation ☐ Volatile chemicals
☐ HAZCAT ☐ Chemical weapons ☐ Biological agents
☐ Other _____

Report results of field safety screening in Appendix 8.3 "Field Testing Results Form."
If any field safety screening result is above the corresponding reference value, immediately notify incident command and do not proceed further into the site.

Initial Observation and Assessment of Immediate Hazards

☐ Unauthorized individuals present at the site
☐ Fire or other obvious hazard
☐ Signs of a potential explosive hazard (e.g., devices with exposed wires)
☐ Signs of a potential chemical hazard (e.g., dead animals, unusual fogs, unusual odors)
☐ Unusual and unexplained equipment at the site
☐ Other signs of immediate hazard _____

If there are any indicators of immediate hazard, immediately notify incident command and do not proceed further into the site.

Report initial observations and results to incident commander.
Approval granted to proceed further into the site? ☐ Yes ☐ No

SITE INVESTIGATION

Time of Entry to Site: _____

Repeat Field Safety Screening

☐ None ☐ Radiation ☐ Volatile chemicals
☐ HAZCAT ☐ Chemical weapons ☐ Biological agents
☐ Other _____

Report results of field safety screening in Appendix 8.3 "Field Testing Results Form."
If any field safety screening result is above the corresponding reference value, immediately notify incident command and do not proceed further into the site.

Signs of Hazard:

- ☐ None
- ☐ Unexplained dead or stressed vegetation
- ☐ Unexplained liquids
- ☐ Unexplained dead animals
- ☐ Unexplained clouds or vapors
- ☐ Other _____

Describe signs of hazard: _____
_____
_____
_____

Unexplained or Unusual Odors:

- ☐ None
- ☐ Sulfur
- ☐ Sweet/Fruity
- ☐ Pungent
- ☐ Skunky
- ☐ New mown hay
- ☐ Irritating
- ☐ Bitter almond
- ☐ Other _____

Describe unusual odor: _____
_____
_____

Unusual Vehicles Found at the Site:

- ☐ Car/sedan
- ☐ Flatbed truck
- ☐ SUV
- ☐ Construction vehicle
- ☐ Pickup truck
- ☐ None
- ☐ Other _____

Describe vehicles (including make/model/year/color, license plate #, and logos or markings): _____
_____
_____
_____
_____

Signs of Tampering:

- ☐ None
- ☐ Open/damaged gates, doors, or windows
- ☐ Missing/damaged equipment
- ☐ Cut locks/fences
- ☐ Open/damaged access hatches
- ☐ Facility in disarray
- ☐ Other _____

Signs of sequential intrusion (e.g., locks removed from a gate and hatch)?

- ☐ Yes
- ☐ No

Describe signs of tampering: _____
_____
_____
_____

Unusual Equipment:

- ☐ None
- ☐ Tools (e.g., wrenches, bolt cutters)
- ☐ Lab equipment (e.g., beakers, tubing)
- ☐ Discarded PPE (e.g., gloves, masks)
- ☐ Hardware (e.g., valves, pipe)
- ☐ Pumping equipment
- ☐ Other _____

Describe equipment: _____
_____
_____
_____

Unusual Containers:

Type of container:

- ☐ None
- ☐ Plastic bag
- ☐ Test Tube
- ☐ Drum/Barrel
- ☐ Box/Bin
- ☐ Bulk container
- ☐ Bottle/Jar
- ☐ Pressurized cylinder
- ☐ Other _____

_____

Condition of container:

- ☐ Opened
- ☐ Unopened
- ☐ New
- ☐ Old
- ☐ Damaged/leaking
- ☐ Intact/dry

Size of container: _____

Describe labeling on container: _____
_____

Describe visible contents of container: _____
_____

Rapid Field Testing of the Water

- ☐ None
- ☐ Cyanide
- ☐ Pesticides
- ☐ Residual disinfectant
- ☐ Radiation
- ☐ Biotoxins
- ☐ pH / conductivity
- ☐ VOCs and SVOCs
- ☐ General toxicity
- ☐ Other _____

Report results of rapid field testing of the water in Appendix 8.3 "Field Testing Results Form."
If any field test result is above the corresponding reference value, immediately notify incident command and wait for instruction regarding how to proceed.

Report findings of site investigation to incident commander.
Approval granted to proceed with sample collection? ☐ Yes ☐ No

SAMPLING

Time Sampling was Initiated / Completed: _____ /_____

Implement Sampling Procedures Appropriate for the Hazard Conditions at the Site:

- ☐ Low hazard
- ☐ Chemical hazard
- ☐ Radiological hazard
- ☐ Biological hazard

If the site is characterized as a chemical, radiological, or biological hazard (as described in Module 3, Section 4.1.3), then special sampling and safety procedures should be followed.

Safety Checklist:

- ☐ **Do not** eat, drink, or smoke at the site.
- ☐ **Do not** taste or smell the water samples.
- ☐ **Do** use the general PPE included in the emergency water sampling kit.
- ☐ **Avoid** all contact with the water, and flush immediately with clean water in the case of contact.
- ☐ **Slowly fill** sample bottles to avoid volatilization and aerosolization.
- ☐ **Minimize** the time that personnel are on site and collecting samples.

General Sampling Guidelines:

- ☐ Properly label each sample bottle.
- ☐ Carefully flush sample taps prior to sample collection, if applicable.
- ☐ Collect samples according to method requirements (e.g., without headspace for VOCs).
- ☐ Add preservatives or dechlorinating agents as specified.
- ☐ Carefully close sample containers and verify that they don't leak.
- ☐ Wipe the outside of sample containers with a mild bleach solution if there was any spillage.
- ☐ Place sample containers into a sealable plastic bag.
- ☐ Place samples into an appropriate, rigid shipping container.
- ☐ Pack container with frozen ice packs.
- ☐ Complete "Sample Documentation Form" (Appendix 8.4).
- ☐ Complete "Chain of Custody Form" (Appendix 8.5).
- ☐ Secure shipping container with custody tape.
- ☐ Comply with any other sample security provisions required by participating agencies.

EXITING THE SITE

Time of Site Exit: _____

Site Exit Checklist

- ☐ Verify that hatches, locks, etc. are properly secured.
- ☐ Remove all samples, equipment, and materials from the site.
- ☐ Verify that all samples are in the cooler and properly seal the cooler.
- ☐ Remove all PPE at site perimeter.
- ☐ Place disposable PPE and other trash into a heavy-duty plastic trash bag.
- ☐ Verify that the perimeter has been properly secured before leaving the site.
- ☐ Ensure that all documentation has been completed before leaving the site perimeter.
- ☐ Comply with any site control measures required by participating agencies.
- ☐ Contact incident commander and inform them that the team is leaving the site.

SIGNOFF

Site Characterization Team Leader:

Print name _____

Signature _____ Date/Time: _____

8.3 Field Testing Results Form

Date of Field Testing:	**Site Name:**			**Field Tester:**		**Phone No.**	
Parameter	**Units**	**Screen[1]**	**Meter/Kit ID[2]**	**Testing Location[3]**	**Testing Time[4]**	**Results[5]**	**Ref. Value[6]**

1: Screening may be conducted for safety, rapid water testing, or both.
2: Report the unique identifier for the meter or kit used during screening.
3: Report the specific location where the field testing was conducted.
4: Report the specific time at which the test was performed.
5: Results of field testing should include replicate analysis where appropriate.
6. Results should be compared with a reference value, if available, to determine whether or not the levels detected pose a hazard.

8.4 Sample Documentation Form

Collection Date:		**Site Name:**		**Sampler:**	**Phone No.**	
Sample ID	**No. Bottles**	**Sampling Time**	**Sampling Location**	**Sample Description**	**Analysis**	**Sample Additives[1]**

1: Report preservatives, dechlorinating agents, acid/base for pH adjustment, and any other sample additives.

8.5 Chain of Custody Form

Site Name:		**Sampler:**	
Sampler Phone No.:		**Signature:**	
Sample ID	**Collection Date**	**No. Bottles**	**Analysis**

Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**

Dispatched by:	**Date/time:**	**Received for Laboratory by:**	**Date/time:**

Method of Sample Transport:		
Shipper:	**Phone No.:**	**Tracking No.:**

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-003
www.epa.gov/safewater/security
December 2003

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

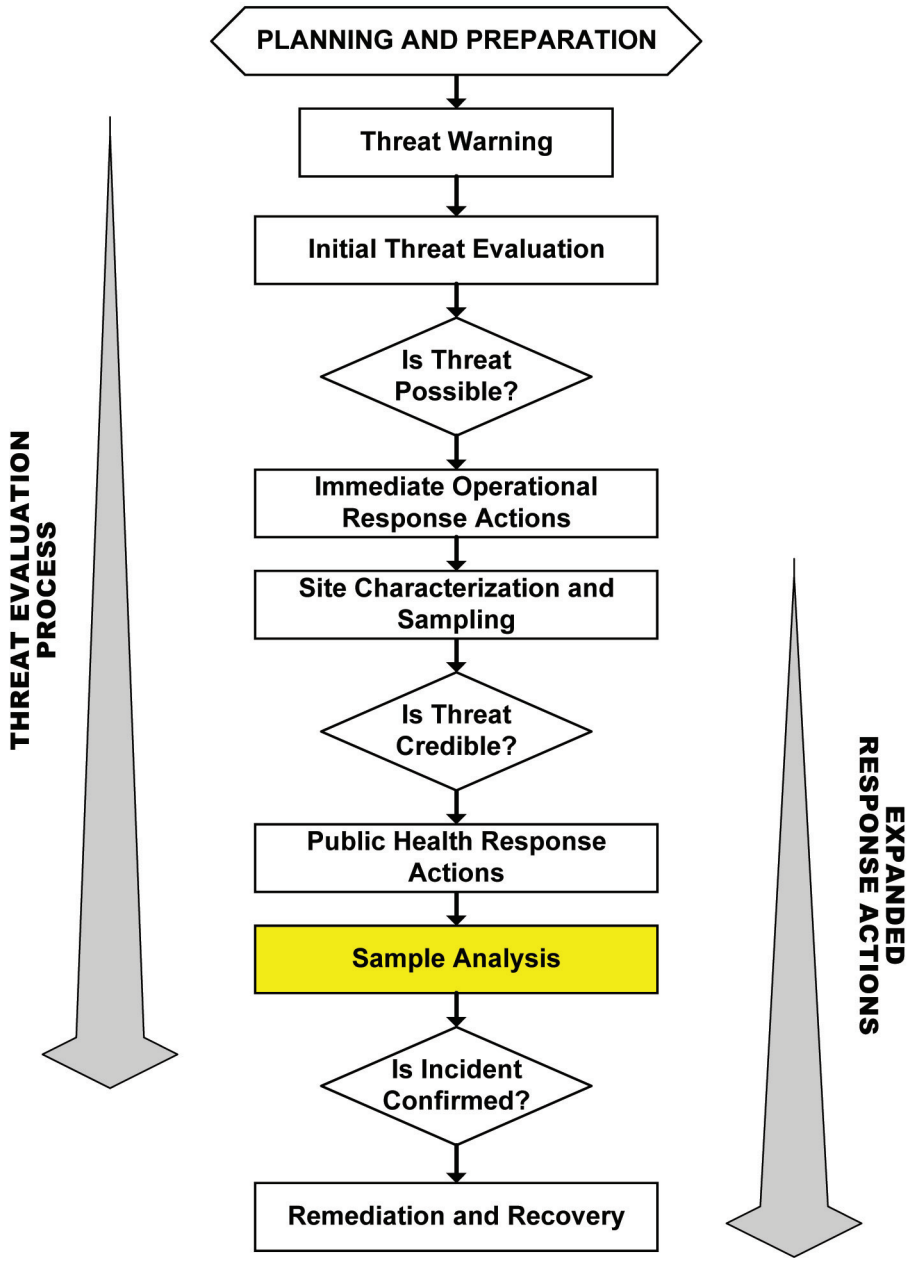
Interim Final - December 2003

Module 4: Analytical Guide

Response Protocol Toolbox:
Planning for and Responding to Drinking Water Contamination Threats and Incidents

Module 4: Analytical Guide

Interm Final - December 2003



OTHER RESPONSE PROTOCOL TOOLBOX MODULES

Module 1: Water Utility Planning Guide *(December 2003)*
Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to prepare for response to contamination threats and incidents.

Module 2: Contamination Threat Management Guide *(December 2003)*
Module 2 presents the overarching framework for management of contamination threats to the drinking water supply. The threat management process involves two parallel and interrelated activities: 1) evaluating the threat, and 2) making decisions regarding appropriate actions to take in response to the threat.

Module 3: Site Characterization and Sampling Guide *(December 2003)*
Module 3 describes the site characterization process in which information is gathered from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Module 4: Analytical Guide *(December 2003)*
Module 4 presents an approach to the analysis of samples collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples that may contain an unknown contaminant. The framework is flexible and will allow the approach to be crafted based on the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Module 5: Public Health Response Guide *(available March 2004)*
Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interactions between the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Module 6: Remediation and Recovery Guide *(available March 2004)*
Module 6 describes the planning and implementation of remediation and recovery activities that would be necessary following a confirmed contamination incident. The remediation process involves a sequence of activities, including: system characterization; selection of remedy options; provision of an alternate drinking water supply during remediation activities; and monitoring to demonstrate that the system has been remediated. Module 6 describes the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

TABLE OF CONTENTS

1 INTRODUCTION 14

1.1 OBJECTIVES AND ORGANIZATION OF THIS MODULE 14
1.2 LABORATORY GOALS FOR RESPONDING TO CONTAMINATION THREATS TO WATER SYSTEMS IN THE CONTEXT OF THE RESPONSE PROTOCOL TOOLBOX 15
1.2.1 SAFETY 16
1.2.2 ANALYTICAL GOALS 17
1.3 ROLE OF LABORATORIES IN RESPONSE TO CONTAMINATION THREATS 18

2 DESCRIPTION OF LABORATORY INFRASTRUCTURE IN U.S. 19

2.1 CHEMISTRY LABORATORIES 19
2.1.1 ENVIRONMENTAL CHEMISTRY LABORATORIES 19
2.1.2 RADIOCHEMISTRY LABORATORIES 20
2.1.3 BIOTOXIN LABORATORIES 20
2.1.4 CHEMICAL WEAPON LABORATORIES 21
2.2 MICROBIOLOGICAL LABORATORIES 21
2.2.1 LABORATORY RESPONSE NETWORK 22
2.2.2 ENVIRONMENTAL MICROBIOLOGICAL LABORATORIES 24
2.3 INTEGRATION OF LABORATORY RESOURCES 24

3 CONSIDERATIONS FOR LABORATORY ANALYSIS OF EMERGENCY SAMPLES 26

3.1 SAFETY 26
3.1.1 HEALTH AND SAFETY PLAN (HASP) 27
3.1.2 PERSONAL PROTECTIVE EQUIPMENT (PPE) 27
3.1.3 COMMUNICATION TO INCREASE INFORMATION QUALITY ABOUT HAZARDOUS SAMPLES 28
3.1.4 SPECIAL PROCEDURES FOR SAFE HANDLING OF HAZARDOUS WATER CONTAMINANTS 28
3.2 LABORATORY INFRASTRUCTURE 31
3.3 DATA ANALYSIS AND REPORTING 33
3.4 QUALITY ASSURANCE AND QUALITY CONTROL 35
3.5 ADMISSIBILITY OF SCIENTIFIC EVIDENCE 35

4 SITE CHARACTERIZATION AND SAMPLING 38

4.1 SITE CHARACTERIZATION 39
4.2 SAMPLING 40
4.3 SAMPLE TRANSPORT AND/OR STORAGE 40
4.4 SITE CHARACTERIZATION REPORT AND CHAIN OF CUSTODY 40
4.5 COMMUNICATION 41

5 GENERAL CONSIDERATIONS FOR AN ANALYTICAL APPROACH FOR UNIDENTIFIED CONTAMINANTS IN WATER 42

5.1 FRAMEWORK FOR DEVELOPMENT OF AN ANALYTICAL APPROACH 43
5.2 INITIAL ASSESSMENT OF AVAILABLE INFORMATION 44
5.3 OVERVIEW OF ANALYTICAL APPROACH FOR UNKNOWNS 45
5.3.1 SCREENING FOR CHEMICALS, INCLUDING “UNKNOWNS” 47
5.3.2 SCREENING FOR MICROBIOLOGICALS, INCLUDING “UNKNOWNS” 48

6 ANALYTICAL APPROACH FOR CHEMICAL CONTAMINANTS 50

6.1 OVERVIEW OF CONTAMINANT ISSUES 50
6.1.1 TYPES OF CHEMICAL CONTAMINANTS COVERED BY THE ANALYTICAL APPROACH 50
6.1.2 SELECTION OF APPROPRIATE METHODS FOR CONTAMINANT ANALYSIS 51
6.1.3 INITIAL PROCESSING OF CONTAMINANTS PRIOR TO LABORATORY ANALYSIS 51
6.2 CONFIRMATORY ANALYSIS 53
6.3 LABORATORY ANALYTICAL SCREENING FOR CHEMICAL CONTAMINANTS, INCLUDING “UNKNOWNS” 55
6.4 BASIC SCREENING USING ESTABLISHED TECHNIQUES WITH STANDARDIZED METHODS FOR TARGET ANALYTES 57

6.4.1 VOLATILES (ORGANIC) ... 59
6.4.2 SEMIVOLATILES (ORGANIC) ... 60
6.4.3 CARBAMATE PESTICIDES (ORGANIC) ... 60
6.4.4 QUATERNARY NITROGEN COMPOUNDS (ORGANIC) ... 61
6.4.5 TRACE METALS (INORGANIC) ... 61
6.4.6 TOTAL MERCURY (INCLUDING ORGANOMERCURY COMPOUNDS) ... 63
6.4.7 CYANIDES ... 63
6.4.8 RADIONUCLIDES ... 64
6.5 EXPANDED SCREENING USING ESTABLISHED AND/OR EXPLORATORY TECHNIQUES WITH STANDARDIZED OR NON-STANDARDIZED METHODS ... 65
6.5.1 EXPANDED SCREENING FOR ORGANIC CHEMICALS ... 67
6.5.2 EXPANDED SCREENING OF INORGANIC CHEMICALS ... 73
6.5.3 EXPANDED SCREENING OF CYANIDES ... 75
6.5.4 EXPANDED SCREENING OF BIOTOXINS ... 75
6.5.5 EXPANDED SCREENING OF RADIONUCLIDES ... 76
6.5.6 EXPANDED SCREENING OF CHEMICAL WEAPONS ... 77

7 EXAMPLES OF THE ANALYTICAL APPROACH TO SITE-SPECIFIC SITUATIONS FOR CHEMICAL CONTAMINANTS ... 79

7.1 EXAMPLES FOR UTILITY LABORATORIES ... 79
7.2 EXAMPLES FOR LABORATORIES WITH A WIDE CLIENT BASE ... 82

8 ANALYTICAL APPROACH FOR BIOLOGICAL CONTAMINANTS ... 86

8.1 OVERVIEW OF CONTAMINANT ISSUES ... 86
8.1.1 TYPES OF BIOLOGICAL CONTAMINANTS COVERED BY THE ANALYTICAL APPROACH ... 86
8.1.2 SELECTION OF APPROPRIATE ANALYTICAL APPROACH FOR CONTAMINANT ANALYSIS ... 86
8.1.3 MICROBIAL SAMPLE COLLECTION CONSIDERATIONS ... 87
8.1.4 MICROBIAL PROCESSING AND ANALYSIS CONSIDERATIONS ... 88
8.2 ESTABLISHED TECHNIQUES FOR SAMPLE COLLECTION OF KNOWN WATERBORNE CONTAMINANTS ... 88
8.2.1 BACTERIA COLLECTION WITH ESTABLISHED TECHNIQUES ... 89
8.2.2 VIRUS COLLECTION WITH ESTABLISHED TECHNIQUES ... 89
8.2.3 PROTOZOA COLLECTION WITH ESTABLISHED TECHNIQUES ... 90
8.3 ESTABLISHED TECHNIQUES FOR ANALYSIS OF KNOWN WATERBORNE CONTAMINANTS ... 90
8.3.1 BACTERIOLOGICAL ANALYSIS WITH ESTABLISHED TECHNIQUES ... 90
8.3.2 VIROLOGICAL ANALYSIS WITH ESTABLISHED TECHNIQUES ... 91
8.3.3 PARASITOLOGICAL ANALYSIS WITH ESTABLISHED TECHNIQUES ... 92
8.4 METHOD FOR SAMPLE COLLECTION, FIELD PROCESSING, AND LABORATORY ANALYSIS FOR UNKNOWN MICROBIAL CONTAMINANTS ... 93
8.4.1 SAMPLE COLLECTION AND CONCENTRATION FOR UNKNOWN MICROBIALS ... 93
8.4.2 FIELD SCREENING AND PROCESSING OF SAMPLE ... 95
8.4.3 PRESUMPTIVE TESTING FOR MICROBIALS WITH EXPLORATORY PCR TECHNIQUES ... 96
8.4.4 CONFIRMATORY TESTING FOR MICROBIALS BY CULTURE AND CONVENTIONAL ASSAYS. 98

9 REFERENCES AND RESOURCES ... 101

10 APPENDICES ... 105

10.1 CHEMICALS THAT APPEAR IN CWC SCHEDULES ... 105
10.2 METHODS USED FOR THE BASIC SCREEN ... 107
10.3 ANALYTE LISTS FOR BASIC SCREEN ... 108

LIST OF TABLES

TABLE 4-1: SUMMARY OF TYPES OF CHEMICAL CONTAMINANTS, THEIR ANALYTICAL GROUP, AND THE CLASS OF CONTAMINANTS DETERMINED BY THE ANALYSIS ... 51
TABLE 4-2: SOURCES OF STANDARDIZED METHODS ... 55
TABLE 4-3: SUGGESTED ANALYTICAL TECHNIQUES FOR PERFORMING THE BASIC CHEMICAL SCREEN, BROKEN OUT BY THE CLASSES GIVEN IN TABLE 4-1 ... 59

TABLE 4-4: EXPANDED SCREENING FOR CONTAMINANTS, BROKEN OUT BY CLASSES OF CONTAMINANTS AS FOUND IN TABLE 4-1 67
TABLE 4-5: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #1 81
TABLE 4-6: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #2 82
TABLE 4-7: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #3 82
TABLE 4-8: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #4 83
TABLE 4-9: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #5 83
TABLE 4-10: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #6 84
TABLE 4-11: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #7 85
TABLE 4-12: BASIC SCREEN FOR CHEMICAL ANALYSIS FOR EXAMPLE #8 86
TABLE 4-13: GENERAL CLASSES OF PATHOGENS, SPECIFIC ORGANISMS, AND SELECT AGENT STATUS. 87
TABLE 4-14: KNOWN WATERBORNE PATHOGENS WITH ESTABLISHED TECHNIQUES FOR SAMPLE COLLECTION AND ANALYSIS 90
TABLE 4-15: EXPLORATORY FIELD SCREENING TECHNIQUES FOR WATERBORNE CONTAMINANTS AND SELECT AGENTS 97
TABLE 4-16: EXPLORATORY ANALYTICAL TECHNIQUES FOR PRESUMPTIVE TESTING OF WATERBORNE CONTAMINANTS AND SELECT AGENTS 98
TABLE 4-17: ESTABLISHED CONFIRMATORY ANALYTICAL TECHNIQUES FOR WATERBORNE CONTAMINANTS AND SELECT AGENTS 100
TABLE 4-18: LIST OF CHEMICALS THAT APPEAR IN CWC SCHEDULES 1, 2, AND 3 106
TABLE 4-19: TITLES OF METHODS USED IN TABLE 4-3 FOR THE BASIC SCREEN 108
TABLE 4-20: ANALYTE LISTS CORRESPONDING TO TABLE 4-3 109

LIST OF FIGURES

FIGURE 4-1: SUMMARY OF TYPES OF LABORATORIES BY CONTAMINANT CLASS 19
FIGURE 4-2: DIAGRAMMATIC REPRESENTATION OF THE LABORATORY RESPONSE NETWORK 23
FIGURE 4-3: SITE CHARACTERIZATION AND SAMPLING PROCESS 38
FIGURE 4-4: DECISION PROCESS FOR THE DEVELOPMENT OF AN ANALYTICAL APPROACH FOR POTENTIALLY CONTAMINATED WATER SAMPLES 43
FIGURE 4-5: INITIAL ANALYTICAL APPROACH TO PROCESSING SAMPLES WITH CHEMICAL CONTAMINANTS 53
FIGURE 4-6: OVERVIEW OF SCREENING AND CONFIRMATORY ANALYSES FOR CHEMICAL CONTAMINANTS 57
FIGURE 4-7: SCHEMATIC FOR BASIC RADIONUCLIDE SCREENING 65
FIGURE 4-8: ANALYTICAL APPROACH FOR THE COLLECTION OF MICROBIAL CONTAMINANTS 88
FIGURE 4-9: APPROACH FOR THE PROCESSING AND ANALYSIS OF MICROBIAL CONTAMINANT GROUPS 89
FIGURE 4-10: BACTERIOLOGICAL SCREENING WITH ESTABLISHED TECHNIQUES 92
FIGURE 4-11: VIROLOGICAL ANALYSIS WITH ESTABLISHED TECHNIQUES 93
FIGURE 4-12: PARASITOLOGICAL ANALYSIS WITH ESTABLISHED TECHNIQUES 94
FIGURE 4-13: SAMPLE COLLECTION AND PROCESSING FOR UNKNOWN MICROBIAL CONTAMINANTS ... 95
FIGURE 4-14: FIELD CONCENTRATOR SCHEMATIC 96
FIGURE 4-15: FIELD PROCESSING FOR MICROBIALS 96
FIGURE 4-16: SAMPLE PROCESSING FOR EXPLORATORY PCR PRESUMPTIVE TESTING 99
FIGURE 4-17: SAMPLE PROCESSING FOR CONFIRMATORY MICROBIOLOGICAL ASSAYS 100

DISCLAIMER

The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACRONYMS

AA	Atomic absorption
AMDIS	Automated mass spectral deconvolution and identification system
AOAC	Association of Analytical Communities (formerly Association of Official Analytical Chemists)
APCI	Atmospheric pressure chemical ionization
APHL	Association of Public Health Laboratories
API	Atmospheric pressure ionization
ASTM	American Society for Testing and Materials
BSL	Biosafety level
BT	Biological terrorism
CDC	Centers for Disease Control
CLIA	Clinical Laboratory Improvement Amendments
CVAA	Cold-vapor atomic absorption
CW	Chemical warfare
CWA	Clean Water Act
CWC	Chemical Weapons Convention
DNA	Deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DOT	Department of Transportation
ELCD	Electrolytic conductivity detector
EPA	Environmental Protection Agency
ESI	Electrospray ionization
ETV	Environmental Technology Verification
FA	Immunofluorescence assay microscopy
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FERN	Food Emergency Response Network
FRMAC	Federal Radiological Management Center
GC	Gas chromatography
GFAA	Graphite furnace atomic absorption
HASP	Health and safety plan
HazMat	Hazardous materials
HHS	Health and Human Services
HPLC	High performance liquid chromatography
HRMS	High resolution mass spectrometry
IC	Ion chromatography
ICAP	Inductively coupled argon plasma
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled plasma optical emission spectroscopy
ICR	Information Collection Rule
IFA	Immunofluorescence assay microscopy
IMS	Immunomagnetic separation
IOC	Intergovernmental Oceanographic Commission
ISE	Ion-selective electrode
ISO	International Organization for Standardization

LC	Liquid chromatography
LLE	Liquid-liquid extraction
LRN	Laboratory Response Network
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCL	Maximum Contaminant Level
MeV	Megaelectron volts
MS	Mass spectrometry
MWCO	Molecular weight cut-off
NEMI	National Environmental Methods Index
NIST	National Institute of Standards and Technology
NRC	National Research Council
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
OSW	Office of Solid Waste
OW	Office of Water
PCR	Polymerase chain reaction
PDA	Photodiode array detector
PID	Photoionization detector
PPE	Personal protective equipment
PSI	Pounds per square inch
QA	Quality assurance
QC	Quality control
RF	Response factor
RIFA	Radioimmunofocus assay
RNA	Ribonucleic acid
RT-PCR	Reverse Transcriptase-PCR
SDWA	Safe Drinking Water Act
SM	Standard Methods for the Analysis of Water and Wastewater
SOP	Standard operating procedure
SPE	Solid-phase extraction
SPME	Solid-phase microextraction
SQM	Semi-quantitative mode
TBD	To be determined
UCMR	Unregulated Contaminant Monitoring Rule
URL	Uniform Resource Locator
USAMRIID	United States Army Medical Research Institute of Infectious Diseases
USDA	United States Department of Agriculture
UV	Ultraviolet
VEE	Venezuelan equine encephalitis virus
VHF	Viral hemorrhagic fever

GLOSSARY

Definitions in this glossary are specific to the Response Protocol Tool Box but conform to common usage as much as possible.

Analyte – the name assigned to a substance or feature that describes it in terms of its molecular composition, taxonomic nomenclature, or other characteristic.

Analytical Approach – a plan describing the specific analyses that are performed on the samples collected in the event of a water contamination threat. The analytical approach is based on the specific information available about a contamination threat.

Analytical Confirmation – the process of determining an analyte in a defensible manner.

Analytically Confirmed – in the context of the *analytical approach*, a contaminant is considered to be analytically confirmed if it has undergone analytical confirmation, as defined herein.

Basic Screen - utilizes standardized methods based on established analytical techniques for the analysis of samples collected in response to a contamination threat.

Biosafety Level 1 – suitable for work involving well-characterized biological agents not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to laboratory personnel and the environment. Work is generally conducted on open bench tops using standard microbiological practices.

Biosafety Level 2 – suitable for work involving biological agents of moderate potential hazard to personnel and the environment. Laboratory personnel should have specific training in handling pathogenic agents and be directed by competent scientists. Access to the laboratory should be limited when work is being conducted, extreme precautions should be taken with contaminated sharp items, and certain procedures should be conducted in biological safety cabinets or other physical containment equipment if there is a risk of creating infectious aerosols or splashes.

Biosafety Level 3 – suitable for work done with indigenous or exotic biological agents that may cause serious or potentially lethal disease as a result of exposure by inhalation. Laboratory personnel must have specific training in handling pathogenic and potentially lethal agents and be supervised by competent scientists who are experienced in working with these agents. All procedures involving the manipulation of infectious materials are conducted within biological safety cabinets or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment. The laboratory must have special engineering and design features.

Biosafety Level 4 – suitable for work with the most infectious biological agents. Access to the two Biosafety Level 4 laboratories in the U.S. is highly restricted.

Chain of Custody – the tracking and documentation of physical control of evidence.

Chemical Weapons – the chemicals that the CWC has placed on its Schedule 1 list.

CLIA Laboratory – a laboratory regulated under the CLIA program.

Clinical Laboratory Improvement Amendments (CLIA) – regulation that covers all laboratory testing (except research) performed on humans in the U.S. Any laboratory participating in the CLIA program that does diagnostic testing, verification, or proficiency testing is exempt from select agent regulation, but the laboratory must follow specific procedures.

'Confirmed' – in the context of the *threat evaluation* process, a water contamination incident is 'confirmed' if the information collected over the course of the threat evaluation provides definitive evidence that the water has been contaminated.

Core Field Testing – analysis performed at the investigation site for radiation, cyanide, residual chlorine, and pH. Core field testing is performed as part of *site characterization* and is composed of two elements, a *field safety screen* and *rapid field testing*.

'Credible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'credible' if information collected during the threat evaluation process corroborates information from the *threat warning*.

Environmental Chemistry Laboratory – any laboratory that is set up to perform analysis of water samples for compliance with the Safe Drinking Water, Clean Water Acts, or other applicable environmental regulation, as well as other chemical parameters that are important to system operation and overall water quality. These laboratories have the instrumentation necessary to implement methods for chemical analysis of a water sample.

Established Analytical Techniques – these techniques are commonly employed in a large number of laboratories and form the basis of many standardized analytical methods.

Expanded Field Testing – analysis of water at the site of a suspected contamination incident for parameters beyond those covered under core field testing (e.g., VOCs, chemical weapons, biotoxins, etc.).

Expanded screen – application of exploratory techniques for chemical contaminants that do not have standardized methods. Additionally, the expanded screen provides laboratories with additional options regarding the instrumentation used to implement both established and exploratory techniques; however, the results may not be considered definitive and thus may require confirmation.

Exploratory Techniques – techniques capable of detecting chemicals that are not included in existing standardized methods. They may employ less common instrumentation than those in the standardized methods, or they may simply not yet be specifically used in standardized drinking water methods.

Field Safety Screening – screening performed to detect any environmental hazards (i.e., in the air and on surfaces) that might pose a threat to the *site characterization* team. Monitoring for radioactivity as the team approaches the site is an example of field safety screening.

Field Sample Concentrate – the term used for the retentate from the ultrafiltration device used for the sampling/concentration of unknown microbial contaminants.

Filtrate – in ultrafiltration, the water that passes through the filtration membrane.

Food Emergency Response Network (FERN) – a laboratory network for the analysis of contaminants in food developed through integration with the existing LRN for pathogen analysis and established forensic chemistry laboratories that serve as reference laboratories for other FDA laboratories.

Grab Sample - a sample collected at random from the source.

Hazard Assessment – the process of evaluating available information about the site to identify potential hazards that might pose a risk to the site characterization team. The hazard assessment results in assigning one of four levels to risk: low hazard, radiological hazard, high chemical hazard, or high biological hazard.

Incident Command System – a standardized on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Incident Commander – the individual responsible for the management of all incident operations.

Infectious – capable of causing infection. In the context of waterborne pathogens, infection is caused by exposure to water.

Laboratory Analytical Screening – application of multiple analytical techniques in a laboratory setting to screen for a wide range of analytes and to confirm tentative results. (Laboratory analytical screening is different and separate from *laboratory safety screening*, *field safety screening*, and *rapid field testing*.)

Laboratory Compendium – a comprehensive, web-based, searchable database of laboratory capability for environmental analysis in water, air, soil, sediments, and other media.

Laboratory Guide – a plan prepared by a specific laboratory detailing their approach and capabilities for the 24/7 processing of emergency water samples.

Laboratory Response Network (LRN) – a network of laboratories developed by the CDC, APHL, and FBI for the express purpose of dealing with bioterrorism threats, including pathogens and some biotoxins.

Laboratory Safety Screening – screening for various hazards that is conducted when samples are received at the laboratory, and which is designed to reduce the risks to laboratory personnel that may handle the samples.

Non-standardized method – a method that does not meet the definition of a standardized method.

Opportunity Contaminant – contaminants that might be readily available in a particular area, even though they may not be highly toxic or infectious or easily dispersed and stable in treated drinking water.

Pathogen - an infectious microorganism that is capable of causing disease.

Personal protective equipment (PPE) – equipment and supplies designed to protect employees from serious injuries or diseasees resulting from contact with chemical, radiological, biological, or other hazards. PPE includes face shields, safety glasses, goggles, laboratory coats, gloves, and respirators.

'Possible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'possible' if the circumstances of the *threat warning* appear to have provided an opportunity for contamination.

Presumptive results – results of chemical and/or biological field testing that need to be confirmed by further laboratory analysis. Typically used in reference to the analysis of pathogens.

Priority Contaminants – list of chemicals, biotoxins, and radionuclides that were ranked highly due to their availability, properties and potential to harm public health if introduced into the drinking water supply.

Rapid field testing - analyzing the water at the site of contamination using rapid field water testing technology to tentatively identify any chemicals or pathogens. Rapid field testing is performed as part of site characterization.

Reference laboratory – the core, advanced technology, LRN laboratories that can provide analytical confirmatory testing of contaminants.

Retentate - in ultrafiltration, the retentate contains the particles that do not pass through the filtration membrane.

Select Agent – biological contaminants, including some pathogens and biotoxins, that are regulated by HHS. Only certain laboratories, registered with the CDC in accordance with the Select Agent Act, are permitted to confirm the presence of, and maintain cultures of, select agents.

Sentinel Laboratory – an LRN laboratory that reports unusual results that might indicate a possible outbreak, and refers specimens that may contain select biological agents to *Reference laboratories* within the LRN.

Site Characterization – the process of collecting information from an *investigation site* in order to support the evaluation of a drinking water contamination threat. Site characterization activities include the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection.

Standardized Method – a method that has been produced as a standard by a recognized method development body (EPA, ASTM, AOAC, ISO, etc.) or applicable regulatory authority. A standardized method has been subjected to review and validation and is capable of generating data of sufficient quality for its intended use. Standardized methods often contain steps to defensibly confirm the presence and/or quantity of specific contaminants.

Tentative Identification – the contaminant identity is hypothesized based on available information from the site characterization report. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; tentatively positive results for a specific

contaminant during field safety screening or rapid field testing; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the disease-causing agent.

Threat – an indication that a harmful *incident*, such as contamination of the drinking water supply, may have occurred. The threat may be direct, such as a verbal or written threat, or circumstantial, such as a security breach or unusual water quality.

Threat Evaluation – part of the threat management process in which all available and relevant information about the threat is evaluated to determine if the threat is 'possible' or 'credible', or if a contamination *incident* has been 'confirmed.' This is an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

Threat Management – the process of evaluating a contamination threat and making decisions about appropriate response actions. The threat management process includes the parallel activities of the *threat evaluation* and making *response decisions*. The threat management process is considered in three stages: 'possible', 'credible,' and 'confirmatory.' The severity of the threat and the magnitude of the response decisions escalate as a threat progresses through these stages.

Ultrafiltration – a filtration process for water that uses membranes to preferentially separate very small particles that are larger than the membrane's molecular weight cut-off, typically greater than 10,000 daltons.

Water Contamination Incident – a situation in which a contaminant has been successfully introduced into the system. A water contamination incident may or may not be preceded by a water contamination threat

Water Contamination Threat – a situation in which the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. Compare *water contamination threat* with *water contamination incident.* Note that even a threat against a water system is a crime under the Safe Drinking Water Act as amended by the Bioterrorism Act.

Water Utility Emergency Response Manager (WUERM) – the individual(s) within the drinking water utility management structure that has the responsibility and authority for managing certain aspects of the utility's response to an emergency (e.g., a contamination threat) particularly during the initial stages of the response. The responsibilities and authority of the WUERM are defined by utility management and will likely vary based on the circumstances of a specific utility.

1 Introduction

1.1 Objectives and Organization of This Module

The primary intended users of this module include laboratory personnel and planners who would provide analytical support to a water utility in the case of a contamination threat to the water supply. This module is intended to be a planning tool for laboratories that may need to provide an analytical response in the case of a contamination threat, **not** a "how-to" manual for use during the actual incident. As part of planning for such an incident, laboratories may want to prepare such a manual specific to their needs and capabilities. They should also exercise and improve the manual from lessons learned via conducting drills, which may encourage laboratories to "think outside the box" in responding to contamination threats.

While this module is not based expressly on regulatory requirements, it should be recognized that **failure to plan for an emergency contamination incident might lead to tragic public health consequences.** Accordingly, the objectives of this document are to:

- Describe special laboratory considerations for handling and processing emergency water samples suspected of contamination with a harmful substance.
- Present model approaches and procedures for analysis of water samples suspected of contamination with a known or unknown substance. These approaches and procedures are developed to take advantage of existing methodologies and infrastructure.
- Encourage planners to develop a site-specific *analytical approach* and *laboratory guide* that conform to the spirit and general principles of the model approaches. Sometimes these models may represent the best and/or only way of dealing with the analytical issues involved. Frequently, they provide an example of the most comprehensive approach.

Planners and laboratory analysts are encouraged to review this module in its entirety, as well as the other modules in the Response Protocol Toolbox, to obtain a more comprehensive understanding of the analytical response approach for water contamination threats. As suggested in the Overview and Application to the Response Protocol Toolbox, the modules that perhaps are most relevant to laboratories are Modules 3 and 4, but depending on the nature of the laboratory, the other modules also may prove helpful. Because of the varied audience for Module 4, particularly certain sections in Module 4, an attempt has been made to provide explanations of the subject matter in the various sections that are directed toward certain audiences. For instance, the bulk of the technical material for the analytical approach is found in Sections 6 and 8. Section 5 describes the framework for the development of an analytical approach, so planners may find Section 5 more useful, whereas laboratory analysts may find the technical material in Sections 6 and 8 more relevant. Furthermore, different laboratories may also require different levels of sophistication in the technical material.

It is hoped that the presentation of the material represents an effective compromise among the needs and capabilities of the wide audience of utilities and laboratories that wish to develop analytical capability to support the evaluation of water contamination threats. This module is organized into ten sections as described below.

Section 1: <u>Introduction</u>: describes the overall organization of the document and discusses the concept of due diligence as applied to laboratories in terms of meeting two main goals: the safety of laboratory personnel and provision of quality analytical data.

Section 2: Description of Laboratory Infrastructure in the U.S.: describes existing laboratory resources that might be involved in the implementation of the analytical approaches presented in this module.

Section 3: Considerations for Laboratory Analysis of Emergency Samples: briefly discusses infrastructure, staffing, personnel safety, and sample capacity considerations for laboratory analysis of water samples suspected to be contaminated with an unknown substance.

Section 4: Field Screening and Sample Collection: provides an overview of the field screening and sampling procedures presented in Module 3 and describes how these activities are linked to laboratory analysis.

Section 5: Analytical Approach for Unidentified Contaminants in Water: presents a framework for developing an analytical approach for emergency water samples in response to a specific contamination threat.

Section 6: Analytical Approach for Chemical Contaminants: presents a tiered approach for the analysis of unknown chemical contaminants, including biotoxins and radionuclides, in water samples.

Section 7: Examples of the Analytical Approach to Site-Specific Situations for Chemical Contaminants: presents examples of how several, hypothetical utility laboratories with differing capabilities have chosen to plan their analytical approach, based on the discussion in Section 6. **Laboratories that choose to perform analysis of emergency water samples and serve a broader client base, such as Federal, State, and commercial labs, may need to adopt a more comprehensive approach, such that they maintain flexibility to provide analytical support in a variety of situations.**

Section 8: Analytical Approach for Microbiological Contaminants: presents a tiered approach for the analysis of unknown microbiological agents in water samples.

Section 9: References and Resources: lists the references used in the development of this module as well as additional information resources.

Section 10: Appendices: provides additional information and materials that may be of value to the reader.

1.2 Laboratory Goals for Responding to Contamination Threats to Water Systems in the Context of the Response Protocol Toolbox

The analytical approach discussed in this module is directed at any laboratory potentially involved in analysis of emergency water samples. Water utilities are most familiar with their own systems, and they are often interested in dealing with incidents of all sorts at the local level (i.e., through the use of their own personnel and their own laboratories). In fact, it is not practical for HazMat responders and hazard materials laboratories to become involved in every incident that occurs at the thousands of

water systems across the country. The responsibility falls on water utilities, who routinely investigate water quality complaints, whether they originate from intentional contamination or not. Accordingly, during intentional water contamination events, it should be the general goal of non-utility laboratories to support the utilities.

For any laboratory to exercise due diligence in responding to contamination threats to water systems, it must meet two specific, essential goals. The first goal is ensuring the safety of laboratory personnel. The second goal is the timely generation of comprehensive, quality analytical results to support difficult decisions that must be made during an emergency situation.

1.2.1 Safety

Specific safety considerations for laboratories wishing to receive and analyze emergency water samples are discussed in more depth in Section 3. It is important to realize that details important for laboratory safety are integrated into the threat evaluation (Module 2) and the site characterization (Module 3) processes, even though they occur outside of the laboratory setting. Information in these other modules impact laboratory safety in several ways. First, the *site characterization* and *threat evaluation* processes help define the hazard conditions at the site of sample collection, which govern who should collect the samples and which laboratories should analyze them. For highly hazardous samples, samples should be collected and analyzed by specifically trained personnel, namely HazMat responders and laboratories that specialize in the handling of specific hazardous substances. This mitigates potential exposure to unprepared laboratory personnel. As an example, if the site characterization results indicate a potential radiological hazard, samples would be delivered only to laboratories that specialize in the analysis and handling of radiological materials.

Second, in the *threat management* process, water contamination incidents range from *'possible'* to *'confirmed'*. The principle set forth in Module 2 is that, to date, there are many, perhaps thousands, of 'possible' incidents (ones that are not really intentional contamination incidents) for every 'confirmed' incident (one in which contamination has occurred). Those incidents falling into the 'confirmed' category are those that generate samples containing a harmful contaminant. Even among those samples, it is expected that the vast majority will not contain highly hazardous materials (e.g., chemical or biological warfare agents or radionuclides). Naturally, there is a continuum, described in Module 2 as *'credible'*, between the 'possible' and 'confirmed' categories. A contamination threat is deemed 'credible' if additional information collected during the evaluation supports the likelihood that contamination has occurred. However, the number of 'credible' cases is expected to be just a few more than the 'confirmed' ones, which is still vastly less than the number of 'possible' ones.

In summary, it is likely that most "emergency" water samples will be sent on the basis of a 'probable' contamination threat. Samples sent to a laboratory as a result of a 'probable' contamination threat should be treated as if they contain a potentially harmful substance. However, the site characterization, along with the threat evaluation process, should result in most highly hazardous samples being screened out before they reach the laboratory. From a safety standpoint, it is important for a laboratory to realize that it will **not be expected to determine every potential contaminant**. For instance, utility laboratories typically may expect to receive samples from 'possible' incidents. The utility laboratories will need additional laboratory support for 'credible' incidents, and specialty laboratories would be called into service for 'confirmed' incidents.

1.2.2 Analytical Goals

Utilities and laboratories familiar with regulatory compliance monitoring are accustomed to thinking about water analysis in terms of contaminant concentrations that may cause chronic (long-term) toxicity. In responding to intentional contamination incidents, an important paradigm shift is that one goal of the analysis may be to help rule in or rule out the presence of significantly elevated levels of certain types/classes of contaminants. Other goals may exist, and their significant features are discussed below.

Analytical goals for the three levels of the threat evaluation process

The threat evaluation process is important to a laboratory's analytical goals, because part of providing timely, accurate results is the proper allocation of analytical resources. The allocation of laboratory resources to a threat will be determined by the analytical goals of the laboratory and the incident's credibility category. Regardless of category, it is important to remember that even if one contaminant is identified during the analysis, the presence of additional contaminants should also be investigated.

- 'Possible' — For the vast majority of cases, because it is unlikely that there will be an actual contaminant, it is very important to report accurate results and to not misidentify an instrumental response. These results need to be rapid, but not instantaneous. Keep in mind that many of the decisions about water system operations will have been made before the analytical results are back from the laboratory. While speed and accuracy are necessary analytical goals for any scenario, they take on a special meaning during the evaluation of 'possible' incidents.
- 'Credible' — In the few 'credible' cases, laboratories may receive water samples containing potentially harmful contaminants; however, the activities performed during the threat evaluation and site characterization processes should reduce the likelihood that samples containing high hazard materials (as defined in Module 3, Section 4.1.2) reach the laboratory. Thus, laboratories should exercise due diligence to meet the goals of protecting their personnel and providing timely, accurate, analytical results. The laboratory investigation should be focused on those types of contaminants discussed in Sections 6 (toxic industrial chemicals, biotoxins, and radionuclides) and Section 8 (some waterborne pathogens, etc.).
- 'Confirmed'— For the rare 'confirmed' incidents, the laboratories receiving these materials should be ones with specific capabilities for the contaminants (chemical, biological, or radiological), which will be suspected or known as a result of the site characterization. Environmental laboratories will be capable of many analyses, but are prohibited from handling materials such as Schedule 1 chemical warfare agents. This Module should **not** be construed to suggest that laboratories intentionally handle materials for which they are not licensed.

Data Interpretation

Another goal of analysis is to interpret data in an appropriate manner. Often, part of the interpretation involves understanding baseline concentrations. **The importance of knowing baseline levels of contaminants at a location cannot be overemphasized.** Not only does this affect the site characterization (Module 3) and threat management process (Module 2) in terms of the proper use of analytical data, but it may serve the larger goal of creating greater public acceptance of water from a distribution system that was once contaminated. Most laboratories currently do not retain this information because they do not necessarily know the sampling location. However, the laboratory may be aware of typical background levels through analysis of routine samples. Laboratories should be aware of issues regarding background data, particularly if they are asked to render an opinion on the presence of an unusual contaminant.

1.3 Role of Laboratories in Response to Contamination Threats

While this Toolbox is aimed primarily at utilities, very few utility labs will be able to independently implement Module 4 in its entirety. However, they may find the information in Module 4 useful in understanding their analytical options, planning their analytical approach, and developing their *laboratory guide*.

Federal, State, and commercial laboratories will play a critical support role in the response to contamination threats – specifically, some of these laboratories will be responsible for implementing the analytical approaches presented in this module. These laboratories may already be familiar with some of the material in Module 4. However, they should work with their utility clients to ensure that the utilities are familiar with the capabilities of the laboratory. In working with the utility, the laboratory should be aware that response to a contamination threat is led by the incident commander, who may be from the water utility. Please see Module 1, Section 4.4 for more details on the Incident Command System and the role of the laboratory within it.

Utilities need to have confidence that laboratories that agree to process emergency water samples operate according to the following guidelines:

- Apply the analytical approach presented in this module according to the circumstances of a particular incident and the needs of the client.
- Maintain facilities and implement procedures for ensuring the security and integrity of samples and analytical results that may be considered as evidence for use in prosecution.
- Receive and process emergency samples 24/7. The laboratory should develop an appropriate plan for staffing, sample receipt, and internal chain of custody.
- Provide results to the client in a time frame stipulated by the client. The laboratory should be prepared to provide the client with an estimate of the time frame in which results may be available. As discussed in Module 2, the utility may need to take certain response measures before analytical results are available. Accordingly, the time frame may be dictated by site-specific factors, such as the hydraulic residency time within a segment of a distribution system.
- Implement appropriate *quality assurance* and *quality control* (QA/QC) procedures, and report the QC data along with the analytical results. See Section 3 for additional discussion.
- Use proper channels for reporting results.
- Provide support in the analysis and interpretation of analytical results.
- Have a back-up plan for processing samples should the laboratory's facility become unusable or unavailable.

Laboratories **may** wish to develop their laboratory guide in accordance with these guidelines, and to share these plans with their clients. Timely and accurate results from the laboratory may provide valuable input for making decisions about how to proceed with a response to a contamination threat. Identification of a harmful contaminant in a water sample would likely trigger additional public health measures, including additional sampling to characterize the spread of the contaminant, and possibly some initial remediation efforts. Likewise, if laboratory results reveal nothing out of the ordinary, the response would likely be terminated, and any precautionary public health measures could be cancelled or scaled down.

2 Description of Laboratory Infrastructure in U.S.

The analytical approach described in the module was developed under the assumption that it would be implemented using existing laboratory infrastructure. If an environmental laboratory response network, designed specifically to analyze environmental samples, is developed in the future, the approaches presented in this document may be revised to take advantage of the new resource. Figure 4-1 summarizes laboratory infrastructure, as it currently exists, for the analysis of environmental samples. Discussion of both access to and roles of these laboratories during the response to an intentional contamination threat or incident follows.

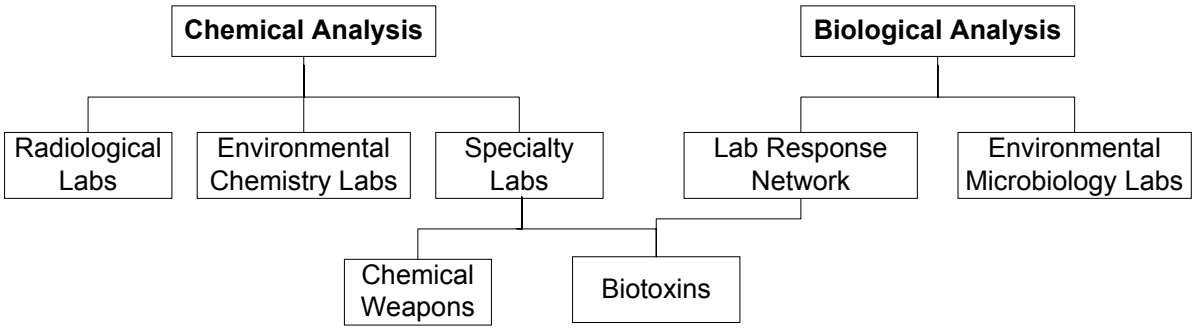


Figure 4-1. Summary of Types of Laboratories by Contaminant Class

The following two sections provide a general description of the laboratory infrastructure for the analysis of chemical and microbiological contaminants in a water matrix. A comprehensive, web-based, searchable database of laboratory capability for environmental analysis in water, air, soil, sediments, and other media will be provided in the *Laboratory Compendium* when available. It is not a listing of laboratories approved, certified, or recommended to analyze samples from intentional contamination incidents. Rather, the Compendium is designed to be a tool for searching for laboratories and determining their ability to perform various analytical techniques, such as those presented in this module.

2.1 Chemistry Laboratories

In addition to laboratories within water utilities, standard and specialized chemistry laboratories within Federal, State, local, city, and municipal government agencies, as well as commercial laboratories, may support analysis of chemicals in water samples. Some laboratory resources may also be available from the academic and industrial sectors. For example, a major chemical manufacturer in an area might want to bring their laboratory operations to bear during the evaluation of an incident in which their products are suspected in a water contamination threat. Many academic and industrial laboratories, however, may not necessarily be set up to rapidly respond to water contamination threats without extensive planning. Regardless of their origin, it is anticipated that four broad categories of analytical chemistry laboratories would play a role in implementing the chemistry procedures in the analytical approach: environmental chemistry, radiochemistry, biotoxins, and chemical weapons.

2.1.1 Environmental Chemistry Laboratories

This group forms the largest sector of the laboratory infrastructure for analysis of chemicals in water, and includes many EPA, State, and commercial water analysis laboratories. Environmental chemistry laboratories are typically set up to perform analysis of water samples for compliance with the Safe

Drinking Water or Clean Water Acts, as well as other chemical parameters that are important to system operation and overall water quality. It is important to realize that these laboratories are typically involved in the analysis of contaminants at concentrations associated with chronic (long-term) toxicity, not the acutely (short-term) toxic levels potentially associated with an intentional contamination incident. While it may seem intuitive that laboratories capable of determining contaminants at low concentrations should not experience difficulties at high concentrations, this is not necessarily the case for a number of technical and practical reasons.

These laboratories typically have the instrumentation necessary to implement *standardized methods* for chemical analysis in a water matrix. Because many of these laboratories are involved in regulatory compliance, the laboratory and staff may already be accredited and certified to implement these methods. However, unless the laboratory tests for the particular chemical *analyte* on a routine basis, the laboratory will not necessarily be able to run the associated method without advanced notice. This includes maintaining an inventory of standards and reagents, setting up the instrument for a particular method, and having staff trained to run the method. This may be particularly relevant in the context of chemical analysis in the case of a suspected intentional contamination incident since many of the chemicals of greatest concern are not routinely analyzed for in water, even though standardized methods are available.

Some environmental chemistry laboratories may have unique capabilities for analysis of select radionuclides or biotoxins, but this is not the expected norm. Analysis for these chemicals may need to be performed by a specialty laboratory as discussed below. Further, there are a number of research laboratories within the government and academic sectors that may be available on a limited basis. These laboratories are typically involved in method development, and thus are equipped with advanced equipment and highly trained analysts that provide capability for implementation of *exploratory techniques* that are currently beyond the means of other environmental chemistry laboratories.

2.1.2 Radiochemistry Laboratories

If a radioactive contaminant is suspected, analyses should be performed by a laboratory specifically equipped to handle such material and analyze for a range of radionuclides. EPA, DOE, States, and commercial firms have laboratories dedicated to the analysis of radioactive and/or nuclear material. For further information about EPA's laboratory services and radiological emergency response programs, see http://www.epa.gov/radiation/programs.htm - er.

Another source of support in the case of an attack utilizing a radiological contaminant is the Federal Radiological Management Center (FRMAC) operated by the Federal Emergency Management Agency (FEMA). FRMAC is set up to provide rapid response teams and emergency management services related to incidents involving radioactive materials. This center works with a number of Federal and State agencies and draws on a variety of resources including fixed and mobile laboratories. FRMAC also maintains databases of national laboratory resources and radiological capabilities. Information regarding FEMA's Radiological Emergency Preparedness Program can be found at http://www.fema.gov/rrr/rep/index.shtm.

2.1.3 Biotoxin Laboratories

Currently, few laboratories are set up specifically for the analysis of biotoxins. Those in existence primarily focus on the analysis of marine biotoxins in coastal waters and seafood products. Some

Laboratory Response Network (LRN) laboratories (see Section 2.2.1) may have the capability to analyze for select biotoxins in water samples, assuming proper sample preparation. In addition, there are a number of laboratories in government and academia that perform biotoxin analysis, usually for other matrices than water (e.g., seafood or agricultural products). It is possible that some biotoxin analyses could be performed in qualified environmental chemistry laboratories using techniques such as GC/MS, HPLC, immunoassay, and possibly LC/MS; however, such capability may not be currently widespread.

2.1.4 Chemical Weapon Laboratories

For the purposes of the Response Protocol Toolbox, a "chemical weapon" refers to those chemicals that the Chemical Weapons Convention (CWC) has placed on its Schedule 1 (http://www.cwc.gov/Regulations/cfr-15/part-712-s1_html). This list includes toxic chemicals with few or no legitimate other purposes, that were developed or used primarily for military purposes (http://www.cwc.gov/Industry_Outreach/Publications/002/cwc-b0001_html). CWC also monitors chemicals on two other Schedules and certain "unscheduled discrete organic chemicals." A list of chemicals in the CWC Schedules appears in the appendix in Table 4-18. Some of these other chemicals (not on Schedule 1) may be present in water through a number of routes other than intentional contamination. For instance, there are some relatively non-toxic chlorinated hydrocarbons listed on Schedule 2 because they can be precursors to Schedule 1 chemicals. Coincidentally, these chemicals may also be disinfection byproducts, a term which refers to the hundreds of substances formed in very small amounts by reactions between drinking water disinfectants and substances naturally present in the water.

Only a few laboratories are qualified and permitted to work with concentrated Schedule 1 chemical weapons surety material. In fact, the only two chemical weapons surety laboratories in the U.S. are the U.S. Army's Edgewood laboratory and Lawrence Livermore National Laboratories. These laboratories can only be accessed through specific channels (e.g., through certain Federal agencies such as FBI). A broader group of laboratories can work with dilute chemical weapons materials, such as might be encountered in a water contamination incident; however, the ability to access these laboratories through normal channels is uncertain, and even if such capability can be accessed, analysis may not be widely available. In contrast, many environmental laboratories work routinely with Schedule 2, Schedule 3, and unscheduled chemicals, and analytical standards for many of these are readily available.

2.2 Microbiological Laboratories

The analysis of waterborne pathogens will likely be performed either by an environmental microbiology laboratory or a laboratory that is part of the Laboratory Response Network (LRN). This may include hospital laboratories, medical laboratories, public health laboratories, and environmental microbiology laboratories. However, the missions and capabilities of these two distinct sets of laboratories are significantly different, and neither may be particularly well prepared for the analysis of all biological terrorism (BT) contaminants of concern in a water matrix. The potential role of each of these types of laboratories in responding to a water contamination threat involving pathogens is discussed in the following two sections.

2.2.1 Laboratory Response Network

The Laboratory Response Network (LRN) was developed by the Centers for Disease Control (CDC), the Association of Public Health Laboratories (APHL), and the FBI for the express purpose of dealing with bioterrorism (BT) threats, including pathogens and some biotoxins (http://www.cdc.gov/cic/functions-specs/function4Docs/nLRNvision-summary.doc). Various laboratories within each State participate in the LRN (see http://www.bt.cdc.gov/emcontact/index.asp for contact information). Laboratories that are part of the LRN can analyze the *select agents* (http://www.bt.cdc.gov/Agent/agentlist.asp) subject to legislative requirements set forth in the Select Agent Regulation (42 CFR 72, http://www.cdc.gov/od/sap). The legislation requires that, subject to certain exemptions, entities possessing biological agents that are listed as select agents must register with CDC and/or USDA's Animal and Plant Inspection Service (for veterinary purposes, http://www.aphis.usda.gov/) and demonstrate compliance with specific safety and security standards for handling these agents.

Two details of select agent regulation (http://www.cdc.gov/od/sap/faq.htm) that might be of immediate interest are: 1) The USA Patriot Act places restrictions on persons who possess select agents and provides criminal penalties for possession of such agents that cannot be justified for specified peaceful purposes (http://www.cdc.gov/od/sap/addres.htm). 2) Any diagnostic or *Clinical Laboratory Improvement Amendments (CLIA) laboratory* that does diagnostic testing, verification, or proficiency testing is exempt from the regulation. However, the director of such a laboratory must notify the Department of Health and Human Services (HHS, see contact info above) immediately upon identifying specific select agents, and it must transfer the agents to a registered facility or destroy them (unless directed otherwise by law enforcement or HHS) within 7 calendar days of identification of the select agent, subject to certain exemptions. Retention of any select agent as a positive control or reference sample is not permitted in this case.

Thus, by legislation, confirmatory analysis of samples containing select pathogens, such as *Bacillus anthracis*, *Brucella* spp., *Yersinia pestis*, *Francisella tularensis*, and *C. botulinum* toxins, among others, must be performed through the LRN. It should be noted that the LRN also performs analysis of biological samples other than the "select" agents, and many of the waterborne pathogens of concern are not select agents. Since the LRN will be involved in an analytical response to any bioterrorism incident, it is important to understand the structure and organization of this network. The LRN, composed of city, county, State, and Federal public health laboratories, is in a perpetual state of evolution as capabilities are matched with current needs. Figure 4-2 provides a schematic overview of the current LRN structure.

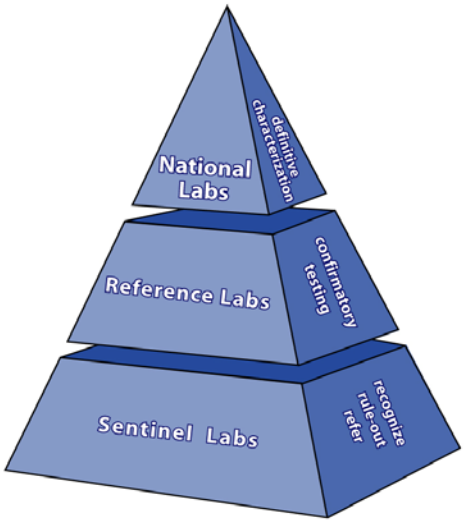


Figure 4-2. Diagrammatic Representation of the Laboratory Response Network

The LRN membership is organized into "*Sentinel Labs*," which recognize an agent, rule it out, and/or refer the sample to the next level for confirmatory testing, performed in "*Reference Labs*". At the top of the pyramid are "*National Labs*" (namely CDC and USAMRIID), which are capable of definitive characterization of even the most hazardous biological agents.

Although the LRN is set up to identify and characterize dangerous pathogens through an upward referral system, most LRN laboratories are not equipped to process water samples that may contain these pathogens or their toxic byproducts. Specifically, they do not have appropriate protocols to process the relatively large sample volumes needed for analysis of pathogens at low concentrations that are still of public health concern. For example, some Reference laboratories have received standardized environmental protocols for handling dry samples that might contain *Bacillus anthracis*, *Brucella* spp., *Yersinia pestis*, *Francisella tularensis*, *C. botulinum* toxins, and *Staphylococcus* enterotoxins; however, protocols are not yet in place for handling water samples containing these agents.

The LRN can accept specimens and samples from hospitals, clinics, the FBI and other law enforcement groups, emergency medical services, the military, and other agencies. Thus, it may be reasonable to expect that water utilities could work through their local or State health departments to deliver samples to LRN laboratories. However, this is complicated by regulations governing the transport of samples that are known or suspected of containing select pathogens. Specifically, such samples can be shipped only in an approved and appropriately marked container (see Section 6 in Module 3 for details, including the use of technical escort services). While these containers are adequately sized to ship clinical specimens and culture tubes, none are of sufficient size or integrity to ship the large volumes of water (a minimum of 10 liters) that are necessary to achieve the desired detection limit. These issues need to be resolved before LRN laboratories can be engaged in the response to a BT incident at a water system. The protocols presented in this module are one proposed solution.

Another challenge arises from the fact that public health and environmental protection are legislated and managed differently by each state. Only four states have a single state agency that is responsible for both public and environmental health. All other states have one agency responsible for public health issues and another for environmental issues. In addition, some states also separate their state public health (clinical) laboratories from the state environmental laboratories. Only 14 state public health laboratories also serve as the state environmental laboratories (Arkansas, Colorado, Connecticut, Iowa, Kansas, Louisiana, Maine, New Mexico, North Carolina, South Carolina, South Dakota, Tennessee, Virginia, and Wisconsin). Personnel at these 14 laboratories, however, rarely handle **both** clinical and environmental samples. Some states even have strict rules that prohibit cross-training of public health (clinical) microbiologists and environmental microbiologists. To further complicate interactions and communications among agencies, the individual responsible for drinking water is located in the health agency in half of the states and in the environmental agency in the other half of the states.

2.2.2 Environmental Microbiological Laboratories

Environmental microbiological laboratories, including those of EPA, state environmental agencies, and the commercial sector, typically perform analyses for waterborne pathogens. Most of these laboratories have the equipment and staff necessary to perform classical microbiological methods, and routinely analyze for indicators of fecal contamination such as fecal and total coliforms and *E. coli*. Culture techniques are available for many of the more common waterborne pathogens such as *Vibrio cholerae, Salmonella enteriditis* Typhi, and *Shigella* spp.; however, analyses for these pathogens are not routinely performed in most environmental microbiological laboratories. While some environmental microbiological laboratories have expanded capabilities to analyze for parasites such as *Cryptosporidium* and *Giardia* or to perform molecular assays for some organisms, these capabilities are not widespread.

While many environmental microbiological laboratories are well equipped to analyze for microbiological contaminants in a water matrix, they generally lack the infrastructure, training, and methods to analyze for many pathogens of concern. Furthermore, as discussed in Section 2.2.1, only laboratories registered for the analysis of select agents are legally permitted to analyze for those agents, and currently most registered labs reside in the LRN. Thus, even if environmental microbiological laboratories develop additional capabilities for pathogen analysis, they could not perform such analyses without registering for select agents.

2.3 Integration of Laboratory Resources

Sections 2.1 and 2.2 presented a brief overview of the laboratory infrastructure that will likely be called upon to implement the procedures presented in this module. While the core infrastructure may exist for both chemical and microbiological analysis, no mechanism currently exists to provide coordination in a manner conducive to optimal analytical response. At a minimum, this will create a greater logistical burden on the organization coordinating sampling and shipment to qualified laboratories. In the worst case, these inefficiencies may result in an incomplete analysis of an unknown, shipment to the wrong laboratory, or delays in receiving time sensitive information.

Formation of environmental laboratory response networks would help to address these coordination issues. Such networks are in existence for the analysis of clinical samples (CDC's LRN) and food samples (FDA's *Food Emergency Response Network* [FERN]). The FERN was developed through integration with the existing LRN for pathogen analysis and establishment of regional forensic

chemistry laboratories that serve as reference laboratories for other FDA laboratories. In the absence of a formal network, the analytical response to water contamination threats may be supported by the laboratory infrastructure as it currently exists.

Accordingly, the approaches described in this module were developed for implementation by the existing laboratory infrastructure. Some states have established/will establish network-like entities to coordinate laboratory efforts. The following steps may help states better integrate laboratory resources and provide a more coordinated response to water contamination threats:

- Establish environmental chemistry laboratories that are capable of implementing both basic and expanded screens (see Sections 6.3 and 6.4) for unknown chemicals in water samples.
- Establish environmental microbiology laboratories within the LRN that are capable of performing Sentinel testing for pathogens of concern in a water matrix.
- Determine those biotoxins that will likely be analyzed for in environmental chemistry laboratories and those that will be analyzed for in LRN laboratories. Considering the range of techniques used to measure biotoxins, there may be some overlap in biotoxin capability.
- Establish a clear sample referral system for the *analytical confirmation* of tentatively identified contaminants, in cases where the *environmental chemistry laboratory* cannot perform it. This concept is integrated into the LRN for microbiological analysis but is not formally defined for chemical analyses.

3 Considerations for Laboratory Analysis of Emergency Samples

Laboratories participating in the analysis of emergency water samples that may contain an unknown and potentially dangerous substance have additional responsibilities beyond those associated with routine analyses. This section briefly discusses some of the special issues related to safety, infrastructure, responsiveness, data reporting, quality assurance, and legal admissibility of scientific evidence that laboratories should consider before engaging in the analysis of emergency samples. This discussion is not intended to comprehensively address all issues that laboratories may face, but focuses on issues specifically dealing with the analysis of emergency water samples. This discussion applies largely to fixed laboratories, not mobile laboratories. Mobile laboratories often are designed to meet specific needs, so it is anticipated that most analyses will be performed by fixed laboratories, which are likely capable of a wider range of analytical methodologies.

This section primarily deals with operations within the laboratory during the analysis of emergency water samples. It is also important, however, for the laboratory to keep in mind its role within the *incident command structure*, which, as discussed in Module 1, is through the "laboratory point of contact." The incident command structure, which must be developed at the local level, establishes and clarifies the roles of each of the various participants (*water utility emergency response manager*, first responders, state drinking water program personnel, laboratory personnel, etc.) and how they should interact with each other.

3.1 Safety

This section seeks to promote the safety of laboratory personnel during the analysis of samples arising from the suspected contamination of the water supply, which is subject to regulations with which most laboratories should be familiar. In addition, the entire Toolbox, including the analytical approach presented in Sections 6 and 8 of this module, is intended to enhance the safety of laboratory personnel. For instance, it is important to realize that during the site characterization process, *field safety screening* and *rapid field testing* have occurred. This may identify potentially hazardous samples before a decision is made regarding the laboratory that will receive the samples. In fact, part of site characterization is the *site hazard assessment*, in which the site is categorized as low hazard, radiological hazard, high chemical hazard, or high biological hazard. The results of this site hazard assessment should dictate the laboratory that will be used for analysis, and they should also help assure that only laboratories equipped to deal with highly hazardous materials will receive samples potentially containing such materials.

Considering that the vast majority of evaluated threats that generate laboratory samples will likely **not** prove to be intentional contamination incidents (see discussion in Section 1.2 of this module), additional risks may be manageable. Due to site characterization procedures, environmental chemistry laboratories may have increased confidence that they will not be processing hazardous biological agents. In the unlikely case that such a sample does reach the laboratory, the measures described below and the analytical approach in Sections 6 and 8 are designed to reduce the risk to laboratory personnel. Accordingly, many more laboratories may be willing and able to help respond to potential intentional contamination incidents.

3.1.1 Health and Safety Plan (HASP)

Under current regulations, laboratories are required to have a plan in place to ensure worker safety. Some laboratories may wish to treat certain emergency water samples as hazardous material as defined in Module 3, whether it be chemical, biological or radiological in nature, and to develop a specific health and safety plan (HASP) to address this potential risk, although there is currently no requirement to do so in most cases. Information on HASPs is available at http://www.ertresponse.com/health_safety/index.htm, along with an electronic expert system jointly developed by EPA and OSHA (http://www.osha.gov/dts/osta/oshasoft/ehasp/) to help determine the appropriate controls of health and safety hazards for a specific situation.

Laboratory personnel involved in the handling and analysis of water samples should have appropriate, current safety training that will allow them to conform to applicable regulations. Laboratories, although not required, may wish to explore some of the measures contained in regulations for the handling of hazardous materials, such as OSHA 1910.120 (http://www.osha.gov). If planners and laboratories do not conclude that these regulations are applicable to them, they may still wish to adopt some of the principles in these regulations. For instance, laboratory personnel may work in cooperation with a designated "buddy" and maintain visual and/or vocal contact with the buddy at all times during the analysis. This system may provide an additional level of protection compared to regulations applicable for most environmental chemistry laboratories, which do not necessarily rely on the "buddy" system.

3.1.2 Personal Protective Equipment (PPE)

Analysis of potentially hazardous samples during an emergency situation may require additional *personal protective equipment (PPE)* above that normally used in the laboratory. Such PPE requirements should be determined during the creation of the site-specific HASP described in Section 3.1.1. The requirements should be contained in the HASP, and PPE should be freely available to laboratory personnel. Personnel should be trained, competent, and medically certified (particularly for respiratory PPE) to use all necessary levels of PPE, in accordance with applicable regulations (i.e., OSHA 1910.120 or OSHA 1910.132 (http://www.osha.gov), along with local or State requirements).

Conventional PPE may be used in conjunction with hand-held "sniffer-type" instruments, which can monitor for a variety of preselected volatile organic and inorganic compounds. References such as http://www.chrismanual.com, http://www.osha.gov/SLTC/personalprotectiveequipment/index.html, and http://www.cdc.gov/niosh/npptl/default.html, should be consulted for more detail on special PPE. For instance, butyl gloves and full-face shields should be considered for optimal protection, particularly during pouring and splitting of non-volatile samples when maximum risk of accidental exposure could occur.

Although not necessarily a personal protection issue, care should be used when using PPE to preserve the forensic integrity of the samples. For example, dirty laboratory coats and gloves could result in cross-contamination of samples. Hair bonnets, aside from some safety benefit, may prevent loose or attached hair from contacting samples, which could potentially introduce a variety of contaminants into the sample.

3.1.3 Communication to Increase Information Quality about Hazardous Samples

Information about the collection site may be an **invaluable** component in personnel safety. In general, laboratories may be asked to analyze samples that originate from two types of sources: 1) those with rigorous sample collection procedures and 2) those using less-than-perfect sample collection procedures. In either case, and particularly the latter, it is recommended that the laboratory be fully informed about the sample collection and site investigation procedures, including any *field safety screening* and *rapid field testing* results, to ensure not only personnel safety but also analytical integrity. The laboratory may wish to take several steps to become more fully informed. One such step is to inquire if the field personnel followed the procedures and performed the tests suggested in Module 3 for site characterization. Another possible step is to establish a system to review procedures used to collect the samples and assess the reliability of the source of the samples. A third step might be for laboratories to enhance their communication with the field sampling teams.

With respect to enhancing communications, representatives from the laboratory ideally would be present during site characterization and sampling to provide as much information as possible to the laboratory analysts regarding sample collection, field screening, sample transport, and eventual analysis. Representatives from the laboratory might then accompany samples to the laboratory and interact with the laboratory personnel while maintaining contact with the field personnel. A less ideal case might be that the laboratory can readily communicate interactively in real time with the field sampling team so that they can provide details of sampling strategies, environmental conditions, and other pertinent information to the laboratory. In any case, the written site characterization report (see Module 3) should be provided to the laboratory at the time of sample delivery or faxed separately. Direct verbal communication, such as a conference call to discuss the site characterization findings, should improve the quality and clarity of the information in such a report.

It is important to note that different organizations may use different terminology when discussing issues related to potential contamination events, ranging from a description of the contaminants, to what is meant by field testing, to descriptions of laboratory results (i.e., is a "negative" result good or bad?). The glossary to this module attempts to standardize these terms, but it is imperative that laboratories ensure that necessary and effective communication is **not** impeded by inconsistent terminology.

3.1.4 Special Procedures for Safe Handling of Hazardous Water Contaminants

<u>Examination of incoming packages</u>

Infrastructure requirements for the safe receipt of packages are discussed in the next section. In addition, the staff in the receiving area should be trained in the identification of safety hazards associated with packages. Sometimes these hazards are indicated by warning labels required by DOT regulations (http://hazmat.dot.gov/) and/or information contained on the shipping papers. Other hazards may result from improper packaging and shipment. They include, but are not limited to: obvious leaks, breaks in packaging tape or custody seals, damage to packaging, unusual stains on shipping container, strange odors, etc. (Note: It is not advisable to smell or taste the package).

<u>Laboratory safety screening upon receipt</u>

During the site characterization process, samples from a site are subjected to field safety screening and/or rapid field testing, as described in Section 4.1 of this module. To reduce risks associated with potential, undetected hazards, laboratories may wish to screen the sample for various hazards upon receipt at the laboratory, regardless of the reported field safety screening results. Specifically, some of the safety screening techniques employed in the field (see Module 3) may also be used in the

laboratory safety screening. Some of these techniques may, in fact, be performed better in the controlled conditions of the laboratory.

If the safety screening tests indicate the presence of a previously undetected contaminant, the sample should be referred to the appropriate laboratory, depending on the type of hazard (radiological, biological, high hazard chemical, low hazard chemical), as described in Section 4, Module 3. For instance, a positive test for radiation would prompt referral of the sample to a radionuclide laboratory, whereas a positive test for cyanide, a low hazard chemical, would allow the sample to remain at the environmental chemistry laboratory and be treated as a cyanide sample.

Avoiding aerosols

The water solubility of potential contaminants sometimes contributes to their safe handling. Namely, as long as the contaminant remains in the bulk aqueous solution, the principal risk involves ingestion. Therefore, **steps should be taken to avoid volatilizing or aerosolizing water samples**, which would then increase the inhalation risk. For instance, the pressurized portion of the *ultrafiltration* device used for concentrating microbial samples (Section 8) is a closed system which prevents the formation of aerosols, assuming there are no leaks. Analytical methods should be appropriately selected to reduce volatilization and the formation of aerosols (e.g., performing extractions in sealed vials). Accordingly, separatory funnel liquid-liquid extraction, which may release aerosols when vented, is not recommended unless laboratories can utilize appropriate hoods or other precautions.

Some aerosol generation is unavoidable. Samples, particularly biological ones, may produce aerosols when shaken vigorously for homogenization, and these aerosols should be contained. Purge-and-trap technology for analysis of volatile organic compounds produces aerosols, which are contained within the instrument, provided that the purge vessel is not accidentally broken during analysis. Also, inductively coupled plasma and some atomic absorption techniques for trace metal analysis must produce aerosols to function properly. For optimal protection, these instruments have to be properly vented to minimize inhalation risk. Manufacturers of modern instruments have designed their instruments to minimize aerosol release (many of these instruments are used in industrial clean rooms), but laboratories should ensure that the venting on their instruments is adequate. If this is not possible, because of the short instrument run times for metal analysis, laboratories may consider performing these analyses after other procedures have been used to screen for the presence of other volatilizable or aerosolizable contaminants.

Dilution

As a general principle, dilution of a hazardous water sample with laboratory-grade water helps reduce risks associated with handling of the sample and its analysis for chemical contaminants. Dilution, however, may have undesirable effects on the ability to detect and quantify the contaminants. Accordingly, it should be used carefully only as part of an overall handling (and/or analysis) strategy that balances contaminant effects (e.g., health and safety concerns) with instrument response and timeliness of the results. Contaminant effects may be important primarily for extremely hazardous chemicals, such as Schedule 1 chemical warfare agents and biological warfare agents. The need to dilute may be reduced by safety screening performed both during site characterization (Module 3) and also upon receipt by the laboratory.

If dilution is desired, “log dilutions” may be attempted. For instance, first, a 1/1,000 dilution may be analyzed, followed by a 1/100 dilution if nothing is detected in the highest dilution, followed by a 1/10 dilution, and finally the undiluted sample. In deciding on a dilution scheme, it is important to keep in mind that most drinking water methods are designed to detect contaminants in the low parts-per-billion

range. Concentrations that are hundreds of times this level may be present in samples from the site of an intentional contamination incident. Appropriate QC measures should be implemented, particularly with regard to the purity of the dilution water. Also, before diluting samples in the laboratory, it should be verified that samples were not diluted in the field prior to shipment to the laboratory.

Although not directly related to safety, dilution may also protect the analytical instrument from becoming saturated with a contaminant. Procedures for reducing the saturation are usually possible, but they take time, limiting the availability of the instrument. Working out the correct dilution requires time, which could be an important consideration. On the other hand, the presence of sufficient analyte to saturate the instrumentation may indicate a significant contamination incident. The decision to implement dilution should accordingly be made during planning.

Reduction of sample volumes used

Like dilution, reducing the volumes of sample handled may help minimize exposure for both chemical and biological contaminants. Some techniques (like those discussed in Section 6) may involve using smaller volumes of sample. For example, direct aqueous injection typically uses a few microliters of sample. Micro-liquid extraction uses about 40 milliliters (mL), and large volume extractions may use 1 liter (L) or more. A sufficient volume of sample is required to achieve the desired detection limits, but it may be helpful to plan the analytical approach based on the desired goals. For example, if the goal is to quantify a high concentration of contaminant (high micrograms per liter), then less sample may be required than for a low concentration (low to mid-micrograms per liter).

Irradiation and other means to reduce pathogenic infectivity, particularly of samples contaminated with both chemicals and pathogens

Some laboratories may consider irradiating (UV or gamma) the samples prior to chemical analysis to reduce the risk of possible exposure to pathogens. There may be other ways of achieving the goal of reducing pathogenic infectivity, such as pasteurization, other heat sterilization, and/or direct filtration. However, all of these approaches to reduce pathogen infectivity may alter the identity and/or quantity of some chemicals by thermal, photochemical, or physical means. Also, in the case of filtration, significant leaching of interfering substances from the filter material can occur. Therefore, when using techniques to reduce pathogenic infectivity, it is important to keep in mind the goals of the analysis, such as analysis of chemicals, detection of viable organisms, etc.

Currently there is no general consensus on proper use of irradiation and/or other techniques to reduce risks associated with sample handling and analysis while maintaining the integrity of the sample and the analysis. Accordingly, these techniques for reducing pathogenic infectivity are not generally recommended (Module 3, Section 4.4.1). The laboratory may wish to explore these techniques, however, if the authorities in charge of the threat evaluation process (Module 2) believe there is very good reason to suspect that the sample is contaminated with both biological and chemical contaminants. In this case, one way to proceed would be to split the sample prior to irradiation. One portion could be irradiated and analyzed for chemicals, and a non-irradiated portion could be analyzed for pathogens, following confirmation that there are no highly hazardous volatile chemicals in the sample. (Note that an irradiated sample could be used for the pathogens, provided the analysis did not require the presence of viable organisms, as is the case with many molecular assays.) Informed decisions could then be made about how to safely proceed with other portions of the original, non-irradiated sample. Appropriate hoods and other physical control measures should be used when handling such samples.

3.2 Laboratory Infrastructure

Infrastructure must be adequate not only to support the analysis of the target analyte in a water matrix, but also must be sufficient to ensure the safety of laboratory staff and the security of samples and data. The following subsections describe infrastructure considerations applicable to all laboratories, followed by those applicable to specific analytical classes. Details of laboratory infrastructure are discussed in more detail in this section, particularly as they relate to safety, security, and analytical quality. This section is not intended to be a laboratory design manual, but rather to highlight areas in which infrastructure considerations may play an important role when handling emergency samples.

General considerations for laboratory capability

The infrastructure must be consistent with the goals of emergency analysis. Ample instrumentation and laboratory equipment should be available to meet analysis goals. This infrastructure should be compatible with relevant laboratory accreditation requirements, quality assurance plans, and requirements of auditing groups. This may help ensure that laboratories function well during an emergency and do not forego sound laboratory practice due to emergency conditions.

Safety equipment

Infrastructure includes any safety equipment such as eyewashes, safety showers, spill containment devices/supplies, etc. It also includes first aid kits, which should include inexpensive antidote kits for various poisons, such as cyanide and organophosphate compounds. Personnel should be trained on the availability, indications, and use of these antidotes. Safety supplies and training materials are readily available from numerous companies servicing industrial safety needs.

Chemical/biological hoods and physical control measures

Appropriate chemical hoods, biosafety cabinets, containment glove boxes, and/or other physical control measures should be incorporated into laboratory infrastructure and may be required by the HASP. Exhaust and pollution control systems must be evaluated to determine proper operation prior to every analysis (i.e., through the use of appropriate monitors for hood face velocity, etc). The chemical hood, biosafety cabinet, and/or containment glove box should be cleared of all other equipment, samples, reagents, supplies, etc., except those required to open and process the sample itself. Some laboratories may wish to deactivate any contaminants that exist on the outside of the sample container or the sample opening equipment. In this case, the deactivating solution (10% bleach, chemical neutralizers, etc) may be kept in the hood or glove box. Note that deactivating solutions, including bleach, have finite shelf-lives and must be refreshed accordingly.

Ventilation and physical control requirements for chemical samples vary with hazard classification. Most laboratories should currently have sufficient controls for low hazard samples. In general, occupational exposure to hazardous chemicals in laboratories is described in OSHA standard 1910.1450 (http://www.osha.gov). This standard also forms the basis for laboratory safety guidelines for laboratories possessing one milliliter or less of a pure Schedule 1 chemical warfare agent (http://www.usapa.army.mil/pdffiles/p385_61.pdf). This link is provided for reference, and should not imply that a laboratory with a liter of water that contains only 10 microliters of pure agent and that has the appropriate physical controls should consider itself an approved laboratory capable of analyzing these substances.

For biological samples, appropriate equipment is required based on the desired *biosafety level* (BSL). For BSL-2, biosafety hoods may be required, while BSL-3 requires a specially designed facility. See http://www.cdc.gov/od/ohs/pdffiles/4th BMBL.pdf for design considerations for biosafety hoods and for more information on BSL requirements for particular biological agents in various forms, e.g. dried

or in solution. For example, although *B. anthracis* is considered an organism that may be safely contained using Biosafety Level 2 (BSL-2, http://www.bt.cdc.gov/documents/PPTResponse/table3abiosafety.pdf) conditions, if the procedure is likely to generate aerosols, it should be handled using BSL-3 conditions.

Sample receipt, handling, and security

Adequate infrastructure is required to achieve the goals of safety for laboratory personnel charged with the receipt, handling, and analysis of potentially hazardous forensic samples. In some cases, the same infrastructure used for receipt of routine samples may be sufficient, but depending on the existing facilities, some upgrades may be necessary to safely handle hazardous samples.

Infrastructure-related safety issues begin with initial sample receipt. The sample receipt area should be isolated from the analysis area and include features that allow effective handling and security of samples. Furthermore, samples should be handled and secured in a manner that will support the admissibility of the results into a court of law. This may include electronic sample tracking and impenetrable storage areas.

Samples should be opened in a manner to maximize personnel safety and minimize laboratory contamination. For example, samples may be opened in a dedicated glove box or hood which is physically and geographically separate from the hoods used in the analytical laboratory. Laboratories may wish to take pictures of samples and/or install automatic video surveillance equipment in order to document sample receipt, handling, and security. Likewise, laboratories may wish to conduct physical measurements (e.g., determine the mass and/or volume of the water sample, upon receipt and at various stages of analysis). This may be important for safety as well as forensic reasons.

Dual-use facilities for routine and emergency samples

For routine analysis, laboratories often can anticipate the concentration range of certain chemicals in water samples and plan accordingly. However, in the case of an unknown, there may not be any information regarding the potential concentration of a particular chemical, and some samples could contain very high concentrations. This can lead to significant problems, such as a laboratory becoming contaminated when unusually high concentrations of a contaminant are present. To minimize the potential for laboratory contamination when working with unknown samples, precautions should be taken, such as working in a dedicated sample prep area, carrying samples in buckets with gas-tight, friction-fit lids containing absorbent material in the bottom, and other measures to physically prevent the accidental introduction of contaminants (including vapors) from water samples into the laboratory.

Aside from safety issues, accurate analytical determinations are related to good laboratory practices, particularly in the area of cross-contamination of samples. (Note that radioactive contamination may be preventable by identifying the presence of radioactivity during initial sample screening procedures.) In addition to degrading the validity of analytical results, cross-contamination can affect aspects of the quality assurance features of a method. For example, contamination of the reagent blank can occur. The reagent blank is an aliquot of reagent water or other blank matrix that is treated exactly as a sample. The reagent blank is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus. If a chemical from an unknown sample contaminates the reagent blank, the accuracy of all subsequent measurements to identify and quantify that chemical in a sample may be compromised. In principle, concerns related to the reagent blank and other related quality assurance issues are procedurally dealt with by the quality control section of the chemical or biological analysis method. However, it is still possible for difficulties to arise, especially

with volatile material that may easily pass through the air from one sample to another or to the reagent blank.

In the case of microbiological contaminants, the high sensitivity of molecular techniques makes them susceptible to contamination by trace amounts of biological materials. For example, molecular methods utilizing the polymerase chain reaction (PCR) are extremely sensitive to the presence of any target DNA. It is imperative that PCR product analysis be carried out in an area physically separated, with separate airflow, from the areas where the samples are prepared for analysis. To avoid contaminating reagents, it is desirable to have a separate reagent preparation facility. These considerations warrant a specialized laboratory facility, specifically designed to deal with the demands of molecular methods. Frequently, a core facility strategy is used to minimize the impact of this space requirement. In this case, there should be separate preparation areas for suspected biological contaminants, to prevent possible cross contamination with routine environmental samples, and to minimize the opportunity for contamination of a laboratory with biological contaminants.

Sample capacity and turn-around time

Laboratory infrastructure involves elements that are desirable for ensuring sufficient analytical capacity and rapid turn-around time in the case of an emergency incident, while maintaining quality standards. This includes elements of laboratory staffing, planning of work schedules, and creating provisions for the availability of staff during an emergency. In addition, the facility should allow for 24/7 access and control of safety measures. For instance, laboratory personnel should be able to override systems that reduce automatic hood ventilation at preset times to save energy. Laboratories may choose to perform frequent exercises to meet the combined goals of analysis speed and accuracy.

Sample disposal

Laboratories should have waste disposal plans in place, subject to applicable regulations. As discussed previously, most samples will likely contain no or little contamination, and hence existing laboratory waste disposal practices should suffice. In the relatively rare instance that the sample does contain a hazard, then it is likely that law enforcement will want the sample retained as evidence and provide guidance as to its storage and ultimate disposition when no longer needed. In any case, all regulations governing the disposal of hazardous substances should be adhered to when disposing of samples.

3.3 Data Analysis and Reporting

The responsibility of the laboratory during an emergency does not end with sample analysis. At a minimum, the laboratory should report the results in a timely manner to the designated recipients. Furthermore, the laboratory may be called upon to assist in analysis and interpretation of the data. While specific arrangements for the reporting and evaluation of analytical results need to be made between the laboratory and the client, the following general guidelines will apply in most situations:

1. The laboratory and the client (e.g., the water utility emergency response manager or the designated incident commander) should agree on the format and content of the report as part of their planning. In this manner, incident command will know what to expect and can practice interpreting the report. There are efforts in the forensic community to provide standardized guidance on report writing (i.e., the minimum types of information that should be contained in such a report). When it is available, this guidance may be included in this module.

   An important issue in the content of the report arises when the laboratory is asked to provide an analysis of a water sample for which the contaminant is unknown (e.g., applying a laboratory

analytical screening procedure to a water sample, as described in Section 6.3). Environmental laboratories are often familiar with determining specific analytes and providing reports regarding those analytes. For example, the laboratory may apply a standardized method and report on the analytes listed in the method. However, if the laboratory observes non-method analytes during the analysis, several questions arise about how theses should be reported, such as:

- What is a significant result in terms of the concentration of the non-target analytes?
- Should all non-detects be reported?
- How much detail is appropriate in identifying and/or quantifying the analytes?

In principle, the report should be thorough enough so that one does not miss anything important, but if too much information is reported, the laboratory may confuse the client. These are complex issues that are likely to be situation-specific and may also be dependent on local policy. Also, reporting priorities may change during the course of the evaluation of a water contamination threat/incident. For example, during the initial phases of the evaluation, the water utility emergency response manager may set a high priority on identifying any unexpected substances in the water, but only above certain concentrations (e.g., normal background levels). Later on, as critical decisions may need to be made, management may be more concerned about analytical confirmation of identification and accurate quantification. Planning and table-top exercises may help the water utility and laboratory decide on what report content is best for them, particularly at various stages of the evaluation.

2. During a suspected contamination incident, it is important that all relevant information be managed through the incident command. This is especially true for analytical results that could be subject to misinterpretation if not placed into the context of the situation. Thus, **analytical results should be reported only to those individuals designated by incident command**, and it will be their responsibility to inform other stakeholders. The water utility emergency response manager (or the designated incident commander) and laboratory contact should be aware of the various applicable Federal, State and local legal requirements, especially for reporting *infectious* diseases. If they are not, the laboratory should inform incident command of these requirements when reporting the results to incident command, provided such reporting is permitted by regulatory requirements.

3. In a crisis situation, the laboratory may be asked to provide tentative results (sometimes called a "rolling report") prior to complete review and confirmation, especially in cases where more than a couple of hours is required for confirmation. **The laboratory may need to provide appropriate caveats regarding the validity of the data at this stage of the analysis.** Depending on the analytical methods used, such caveats, perhaps in the form of a clearly presented narrative summary, might include: methods and techniques used, the probability of false negative/false positive results, limit of detection, method accuracy/precision, quantitative versus qualitative results, and the time necessary to confirm tentative results. It is the responsibility of incident command to weigh all of this information and make decisions about appropriate response actions.

4. The laboratory should be available to assist in the analysis and interpretation of the results. Not only will the laboratory staff have a unique perspective regarding the reliability of the method and interpretation of results, but they also may have substantial experience with the application of the methodology to other samples. Thus, the analyst may have the ability to discriminate

between results that fall within the normal range of occurrence and those likely to be indicative of an actual contamination incident. As an example, chloropicrin and cyanogen chloride are potentially hazardous chemicals at high concentrations in water. However, these same compounds can occur at very low levels in disinfected drinking water as disinfection by-products, resulting from the reaction of the disinfectant with materials naturally present in the water. An analyst with experience determining these compounds would likely recognize elevated levels outside of the range typically encountered in treated drinking waters. **The issue of baseline (background) levels is critical to the interpretation of analytical results and thus to the threat evaluation (Module 2)**. A more difficult interpretation of the results would occur if low levels of such "naturally occurring yet potentially hazardous contaminants" are detected, since these levels could represent typical background **or** the tail of a transient contaminant slug, in which case additional sampling and analysis may be necessary.

3.4 Quality Assurance and Quality Control

Standardized methods available in fixed laboratories are designed and verified to provide accurate and defensible results. However, methods for analysis are only as good as the people who perform them, assuming suitable analytical technology is at their disposal. It is common experience that some individuals obtain better results from analytical methods compared to others due to the skill level of the analyst, and this may be particularly true during the analysis of an unidentified contaminant using *non-standardized methods*, as discussed in Section 6. To address these types of concerns, EPA has developed extensive guidelines regarding the quality of data generated internally and for non-EPA organizations. For more details, see http://www.epa.gov/quality1/exmural.html#genreqts.

There are currently specific QA plans/guidance being developed for forensic analysis of unknowns for both biological and chemical samples. This QA guidance may be included in a future version of this module. Many laboratories may already have quality assurance plans that meet these requirements. Until (and after) this QA guidance is formalized, laboratories should be aware of legal issues involving admissibility of scientific evidence, as discussed in the following section.

One consideration with respect to QA/QC for analytical methods used during the evaluation of suspected water contamination incidents is the objective of the analysis. For instance, one goal may be to qualitatively confirm the presence of a particular contaminant. Another goal would be to quantitatively determine the concentration of a contaminant. Selecting the objectives of a particular analysis is part of planning for a site-specific response to a contamination threat. In many cases, the threat evaluation process discussed in Module 2 will drive the purpose of the analysis toward quantifying chemicals at concentrations from milligrams per liter to low micrograms per liter of chemicals, and pathogens at their infective doses. The analytical approach presented in Sections 6 and 8 reflects this goal. However, depending on the specific plan, other goals may be applicable.

3.5 Admissibility of Scientific Evidence

If criminal or terrorist activity is the suspected cause of a contamination incident, any samples collected and analyses performed may be considered evidence by law enforcement agencies. Many environmental chemistry laboratories are currently performing water analyses to support regulatory compliance, and they are familiar with the need to treat samples with precautions necessary for legal defensibility. Analysis for regulatory compliance purposes, however, may operate somewhat differently than analysis of emergency samples in response to a contamination threat, which has the

dual role of both providing an emergency response to protect public health and also supporting a criminal investigation.

The objective of the emergency response is to provide the water utility emergency response manager (or the designated incident commander) with timely and accurate scientific results (Module 1). Supporting a criminal investigation may involve additional time and effort. Improper decisions made during emergency response may also result in public outcry and/or legal action, whether criminal or civil, so the quality of data required for a response action may rival that of the criminal investigation.

Meeting these dual goals requires careful planning and analysis of the public health needs and legal requirements in place for a specific location. Nevertheless, utility planners should be aware that most of the groundwork is already in place at laboratories, and may be readily built upon through appropriate selection of the analytical approach, as well as training exercises. Some of this groundwork is described below.

To maintain the credibility of evidence throughout the sampling and analysis process, the laboratory must demonstrate an unbroken *chain of custody* and ensure that basic principles of admissibility of scientific evidence are met. Chain of custody begins with sample collection and shipment to the laboratory. Sample custody typically becomes the responsibility of the laboratory upon sample receipt. Documentation should clearly track the sample and analytical results from the point of sample receipt through reporting of results. Furthermore, when designated laboratory staff are not in possession of the sample or related information, it should be secured. If there are gaps in the chain of custody or periods during which the sample or results could have been compromised, the analytical results could be dismissed by the court. In cases in which the analysis leads to prosecution of a perpetrator, chain of custody should continue until law enforcement has determined that any remaining sample is not needed as evidence.

Certain principles govern the admissibility of scientific evidence in a court of law, and laboratories processing samples considered as evidence should adhere to these principles to improve the legal defensibility of their results. There are no universally accepted criteria for the admissibility of scientific evidence, although State and Federal courts typically use one of three standards: Federal (or State) Rules of Evidence, the Frye standard, or the Daubert standard. A more detailed discussion of the admissibility of scientific evidence can be found in the *Reference Manual on Scientific Evidence, 2nd ed.*, which can be downloaded from the Federal Justice Center's web site at http://www.fjc.gov/public/pdf.nsf/lookup/sciman00.pdf/$file/sciman00.pdf.

Note that in the case of scientific evidence, states may develop their own criteria, other than Frye or Daubert, which are more stringent than the relevancy issue considered in the rule of evidence.
In considering the principles that govern the admissibility of scientific evidence in the context of the analysis of water samples for known or unknown contaminants, it is most useful to consider the most stringent standard – Daubert. It is clear that a laboratory would play a crucial role in the selection and implementation of an analytical approach that would result in data that would pass the Daubert tests. There are currently efforts underway in the forensic community to prepare guidance for proper implementation, particularly as it refers to the validity of the analytical results. While this guidance is not available at this time, it may be included in future versions of this module. In the meantime, a few example areas that should be addressed that would aid in meeting the Daubert standard include:

- Quantification of Type I (false positive) and Type II (false negative) error rates through appropriate quality assurance and quality control (QA/QC).

- Use of standardized methods, or methods that have been subject to rigorous peer review if standardized methods are unavailable.
- Participation in a certification or accreditation program for the relevant methodologies.
- Participation in interlaboratory studies (or third-party performance evaluation studies).
- Supporting documentation for methods, SOPs, QA plans, etc.
- Training and competency testing for analysts.
- Special training for scientists and analysts required to give expert testimony.

4 Site Characterization and Sampling

While this module focuses on the analytical approach, laboratory personnel need to have a basic understanding of the processes implemented prior to transfer of sample custody to the analytical laboratory. This understanding may be of value to the laboratory for the purpose of developing procedures for sample receipt that will ensure the safety of laboratory personnel, a meaningful analytical approach, the timeliness and quality of the analysis, and the legal defensibility of the results.

The processes leading up to sample analysis, namely site characterization and sampling, are covered in detail in Module 3, "Site Characterization and Sampling Guide," but it is worthwhile to briefly discuss a few points here. Readers are encouraged to refer to Module 3 for more complete explanations and extensive description of site characterization activities, including a general discussion of **who** will perform the activities under various hazard conditions. Figure 4-3 illustrates the steps leading up to sample shipment. The glossary provides definitions of terms used.

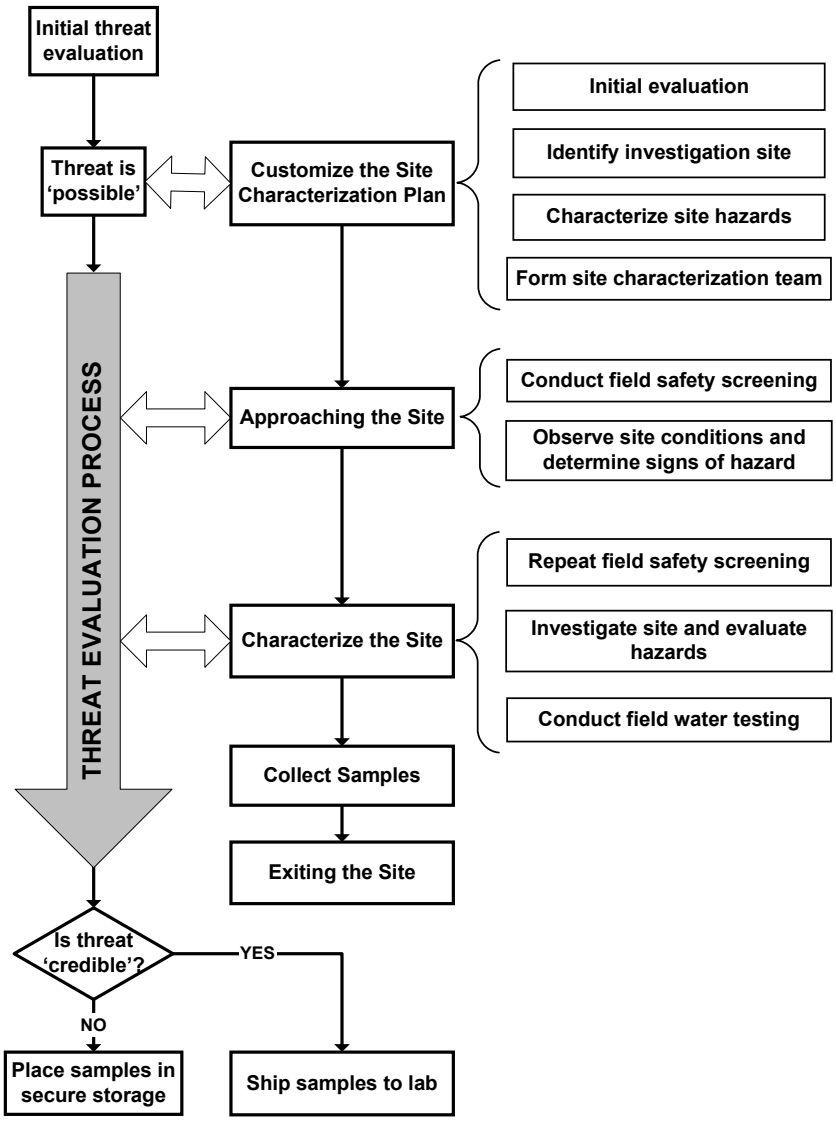


Figure 4-3: Site Characterization and Sampling Process

4.1 Site Characterization

The left side of Figure 4-3 shows the *threat evaluation* process conducted in parallel with the site characterization and sampling procedures. Throughout the entire evaluation of the incident, the credibility of the threat is continually reevaluated as new information becomes available. If at any point the threat is determined to be not credible, the process is discontinued. Thus, samples might only be sent to the laboratory if the threat is still deemed credible following sample collection, as indicated in Figure 4-3. The threat evaluation protocol is discussed in more detail in Module 2.

The site characterization process begins with an evaluation of the site hazards. Based on the available data and initial threat evaluation, a determination will be made regarding the need to implement special hazardous material handling techniques. This may dictate the organization or team that is sent to the site to perform field screening and sampling. While it may be necessary to consider the details of a specific threat/incident when determining the level of protection required for the response team, planning for a response to various scenarios should occur well in advance of an actual threat. Specifically, response plans should document who would be called to respond to contamination threats under different hazard conditions.

Upon site entry, *field safety screening* protocols may be implemented. The purpose of field safety screening is to detect any immediate threats to the response team from contaminants in the atmosphere or on surfaces. Core safety screening focuses on threats from radiation, but the safety screening may be expanded to include volatile chemicals, chemical weapons, and biological weapons as appropriate for the situation. If any of these threats are detected, it would likely be necessary to immediately evacuate the site and send in teams properly equipped to deal with the hazard tentatively identified during the safety screening. The site characterization team should have training in the uses of safety screening equipment (see section 4.2.2 of Module 3) and be familiar with its capabilities and limitations.

After the field safety screen has been completed, the appropriate team may continue the site characterization, including *rapid field testing* of the water. Recommended *core field testing* consists of radiation monitoring (in the water), cyanide, chlorine residual, and pH. Section 4.3.2 of Module 3 discusses options for *expanded field testing*. Note that these core tests are based on historically reliable or verified technology. **Few of these technologies for rapid field water testing beyond the core tests, however, have undergone a thorough and independent performance evaluation. Without reliable performance data, any field testing technology for chemicals, pathogens and/or radionuclides should be used with caution. The same is true for technology for safety screening, particularly for biological contaminants.** This document is somewhat forward looking, and it assumes that some of the existing kits will provide some useful data; however, these kits have not yet been verified. Verification of several of these technologies is being carried out through EPA's Environmental Technology Verification program in 2003, and the verification reports can be found, when available, at http://www.epa.gov/etv/.

There are three objectives of field testing the water: 1) provide additional information to assess the credibility of the incident; 2) provide *tentative identification* of contaminants that would need to be *analytically confirmed* in the laboratory; and 3) determine if hazards tentatively identified in the water require special precautions during sampling. Note that these goals are distinct from the analytical testing that occurs at the laboratory, even if the same technology is employed at the laboratory as part of their safety screen upon sample receipt (Section 3.1.4).

4.2 Sampling

After field testing is completed, samples may be collected using those precautions appropriate for the hazards identified. A sampling kit that contains bottles and supplies for the proper collection and identification of each sample should be available. In Section 4.2.2 of Module 3, Table 3-1 describes such a sampling kit. Note also that Table 3-1 does not contain any personal protective equipment, except that required to add the chemicals used to preserve the samples. If any personal protective equipment is required, it should be included as part of the health and safety plan (HASP) included in the sample kit (Table 3-1).

In general, samples for chemical analyses may be collected in clean glass or plastic containers according to sampling procedures appropriate for the analysis. The specific sample containers suggested for chemical analytes are listed in Table 3-2 of Module 3, and correspond to the particular analysis in the analytical approach set forth in Sections 6 and 8 of this module. The table lists the number, type, and volume of each sample container, as well as any preservatives or dechlorinating agents appropriate for the sample. Laboratories may find the information in these tables useful to increase their familiarity with incoming samples.

4.3 Sample Transport and/or Storage

The process flow chart in Figure 4-3 indicates that samples would typically be collected after field testing regardless of threat credibility; however, a decision must be made whether or not to send samples to the laboratory immediately following sample collection. This decision should largely be based on the outcome of the threat evaluation. If the threat is deemed credible, the samples may be sent to the appropriate laboratory for immediate analysis. Packaging and transport of the sample to the laboratory is discussed in Section 6 of Module 3. If the threat is not deemed credible, the process is halted; however, some analysis may still be performed on the samples at the discretion of the utility or other parties involved in the response.

If samples are not sent to the laboratory for analysis, they should be held in cold storage (protected from freezing at 4° C) under safe and secure conditions for at least one week following collections, and possibly longer if dictated by other parties that could be involved in the response (FBI, CDC, EPA, etc.). If the samples are stored, then the samples must be securely stored and appropriately preserved (Section 4.2). Proper chain-of-custody procedures should be maintained, and holding times must be within acceptable bounds to meet the analytical goals for the contaminant of interest.

4.4 Site Characterization Report and Chain of Custody

Chain of custody is initiated at the time of sampling, along with other sampling documentation. If samples are sent to the laboratory, all relevant documentation should be submitted at the same time including:

- Contact information for the sampling organization.
- Sample documentation, including chain-of-custody forms.
- Details about any pretreatment performed on the samples in the field, such as dilution, preservation, dechlorination, etc., if not already included elsewhere.
- Site characterization report, including site investigation forms, field safety screening results, and results from rapid field testing conducted on the water.
- The current stage of the threat evaluation. Note: the laboratory should be cautioned **against** reducing handling precautions for lower threat evaluation stages without good reason.

- Instructions on data reporting (i.e., to whom, what format, special reporting requirements, etc.).

This information may be of tremendous value in the development of an analytical approach for a water sample that may be contaminated with a harmful substance, as discussed in greater detail in Section 5. The laboratory should be aware that the site characterization report may be incomplete and/or inaccurate. If the laboratory has any questions, communication (see section 4.5 below) becomes extremely important. The laboratory may also wish to verify the preservation and/or dechlorination of some arriving samples (e.g., through the use of test strips for free chlorine and pH). Deviations from the preservation and/or dechlorination described on the sample documentation should be noted by the laboratory, and the laboratory should adjust their sample processing accordingly.

In addition, chain-of-custody procedures should be followed carefully to support future criminal and/or civil legal action regarding the incident. Chain-of-custody should not stop with sample receipt but should also include an internal chain-of-custody procedure. Internal chain-of-custody should be established for all samples regardless of any questions about chain-of-custody maintained prior to receipt by the laboratory.

4.5 Communication

Multiple laboratories may be involved, depending on the nature of the analytes. **All relevant laboratories should be included in the communication process.** Communication between the laboratory(ies) and sampling team should begin no later than the time of sample collection, especially in the case of a highly credible threat. In some cases, a laboratory may choose to send personnel to the site to ensure that proper sampling techniques are followed, assist in the interpretation of field test results, and facilitate chain of custody. This interaction may help laboratories identify any potential hazards associated with the samples and consider site-specific information in developing an analytical approach for the specific incident. If laboratory staff cannot be present during sample collection, a conference call might be scheduled to discuss the information outlined above, as it relates to laboratory safety and development of an analytical approach, which is discussed in more detail in the following section.

Communication should be appropriately documented for future reference. Written notes may be taken, and electronic recording devices may be used, but only to the extent allowed by privacy laws, particularly for telephone conversations.

5 General Considerations for an Analytical Approach for Unidentified Contaminants in Water

In the case of a water contamination threat, it will likely be necessary to make rapid decisions, based on limited information, about the contaminants that will be evaluated by the laboratory. These decisions may impact the samples that are collected, selection of the laboratory, and the specific analyses that would ultimately be performed (defined as the *analytical approach*). In some cases, evidence from the site or results from field screening may provide some indication about the identity of the contaminant, and the analytical approach can be adjusted accordingly. However, it is generally assumed that the presence and identity of a contaminant in the water sample would need to be *analytically confirmed* with limited evidence to guide the analysis. Furthermore, even if a tentative identification of the contaminant has been made in the field, circumstances may warrant analysis for other contaminants in addition to those tentatively identified.

A number of officials from various organizations, including the laboratory, may need to be involved in the development of an analytical approach **in response to a specific contamination threat**. During the response to a contamination threat, the laboratory would need to establish clear lines of communication with incident command, the affected utility, sampling teams, and any other stakeholders that are not coordinated directly through incident command. This collective group of decision officials would need to evaluate available information and work together to develop an analytical approach that is appropriate for the circumstances of the specific threat.

The analytical approach may need to be developed rapidly – in a time frame of minutes to hours. **Planning, preparation, and communication are key to making such decisions in a rapid and effective manner.** After careful planning, laboratories may wish to formalize their analytical and management approach in a **laboratory guide** that is analogous to the **response guide** (Module 1) prepared by utilities that summarizes the actions the utilities plan to take during an emergency.

This section lays out a framework for developing an analytical approach in response to a specific contamination threat. The technical aspects of the analytical approach for chemicals and pathogens are described in Sections 6 and 8, respectively. Hypothetical examples of specific approaches developed to meet site-specific objectives are given in Section 7. While this framework may be used in real-time during a response, it should also be used for preparation and planning for such a response. Laboratories and their customers (utilities, States, Federal agencies, etc.) should work though this process under various test scenarios to become familiar with the process, and to understand the capabilities and limitations of a laboratory in implementing the approaches described in Sections 6 and 8. Laboratories may find they need to expand their capability in a particular area to provide adequate coverage for target analytes, or it may become apparent that limitations may require use of other laboratories for some specialty analyses.

This section is intended not necessarily for laboratories, which may be more interested in Sections 6 and 8, but for planners and managers, who may be more interested in the concepts involved. Section 5 is divided into three subsections. The first subsection presents a decision tool that may serve as a model for the development of an analytical approach to a specific contamination threat, based on different levels of tentative identification. The next subsection, "Initial Assessment of Available Information" describes potentially useful information from a specific contamination threat to support the development of an analytical approach. The final subsection describes the general approach used for the analysis of unknown contaminants.

5.1 Framework for Development of an Analytical Approach

Once the decision to send samples to a laboratory for analysis has been made (see Section 4), it will be necessary to develop an analytical approach that is appropriate for a specific contamination threat or incident. Figure 4-4 presents a decision tool that is intended to aid in the development of the analytical approach. Figure 4-4 is geared towards the analysis of water samples potentially containing an unknown chemical or biological contaminant that was collected from a site characterized as having low hazard conditions. It is assumed that radiation screening has been performed prior to the start of Figure 4-4. In particular, if the field testing results for radiation were positive, one would go down an entirely different, and fairly well-defined, analytical path (see Section 6.4.8).

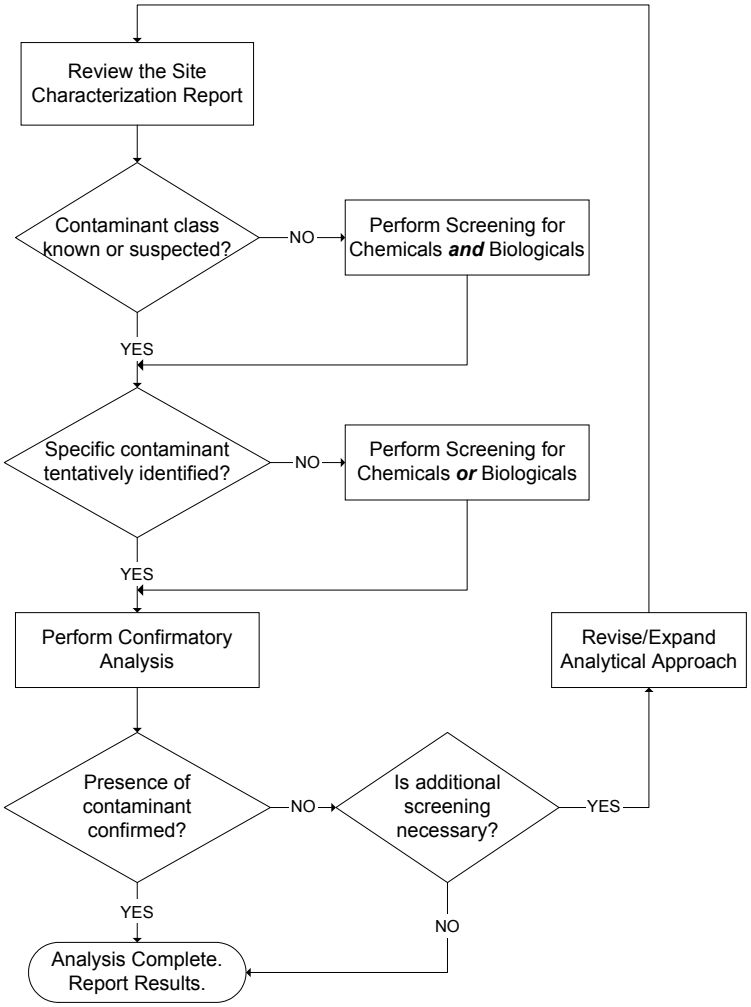


Figure 4-4. Decision Process for the Development of an Analytical Approach for Potentially Contaminated Water Samples

It is important to emphasize that the decision process depicted in Figure 4-4 should be used as a planning tool, not just during an incident. Laboratories, in conjunction with their clients, should work through this process **prior** to an emergency situation to develop and refine their own analytical plans and procedures. The decision process begins with an evaluation of available information about the contamination threat that might be of value in developing an analytical approach. The information used to support this initial assessment is described further in Section 5.2 and in greater detail in Module 2.

The first decision point in the process is an assessment of whether or not there is sufficient information to make a tentative identification of the contaminant as chemical and/or biological. If this is possible, then an entire class of contaminants is eliminated from consideration, allowing focus on the tentatively identified contaminant class. If the information is not sufficient to make a determination between chemical and biological contaminants, then the sample may be treated as a complete unknown. The recommended analytical approach for a complete unknown is described in Section 5.3.

The second decision point involves tentative identification of the specific contaminant. At this point, the contaminant identity is hypothesized based on available information from the site characterization report. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; tentatively positive results for a specific contaminant during field safety screening or rapid field testing; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the disease causing contaminant. It is important to note, however, that each of these situations has a different level of credibility for the purpose of tentative identification. In general, tentative identification may focus the analytical approach on the specific contaminant subclass, leading to confirmatory analyses for the particular contaminant. For example, tentative identification of a class of pesticides (e.g., organophosphates) may be based on results from a test kit, and this information might be used to focus the analytical approach on specific pesticides within that class. Depending on the strength of the tentative identification, as determined with due diligence by the water utility emergency response manager, it may be wise to consider heading down both paths simultaneously (Module 2). If the evidence for tentative identification is sufficiently strong, then screening may be delayed. Otherwise, screening for a broad array of potential contaminants should begin simultaneously with the confirmatory analysis for the tentatively identified contaminant.

The third decision point is based on the results of the confirmatory analysis used for the tentatively identified contaminant. If the presence of the contaminant was analytically confirmed, then the results are reported to incident command. In the case of potential multiple contaminants, multiple analyses may be required before incident command decides if the analysis is complete. (Note: For the purpose of this document, analytical confirmation refers to the legally defensible identification of an analyte. There are efforts in the analytical forensic community to rigorously define what constitutes confirmation, and results of these efforts may be included in later versions of this module. In the interim, laboratories should pay careful attention to principles that govern the admissibility of scientific evidence [Section 3.5].)

The fourth decision point involves the possibility of additional screening for chemicals or biologicals if the presence of the tentatively identified contaminant was not confirmed or additional contaminants are suspected. At this point, communication between the laboratory and incident command will likely be necessary, because the decision to perform additional screening may be based on recently available information regarding the threat. For example, new evidence may come to light indicating that, despite initial indications, the threat is no longer credible. However, in case the threat is still deemed credible, it may be necessary to revise and/or expand the analytical approach, possibly in conjunction with a fresh review of the site characterization report.

In any situation involving tentative identification of a contaminant, the reliability of the information should be carefully evaluated. In some cases, it may be determined that the source of information is too unreliable to provide the basis for a tentative identification. For example, if a specific contaminant is named in a threat made over the phone, the reliability of the information might be considered suspect. In this case, the analytical approach might start with the named contaminant, but additional

screening might be warranted depending on other considerations such as the credibility of the incident. For this reason, development of the analytical approach may be iterative, as indicated by the decision point "Is additional screening necessary?" If the answer to this question is "yes," available information would be reevaluated to refine or broaden the analytical approach.

5.2 Initial Assessment of Available Information

While previous water contamination threats may indicate that the most likely scenario is an unknown contaminant, it is possible that there may be some information from the incident that may inform the development of the analytical approach. For example, negative results from reliable field tests may eliminate some contaminant classes from further consideration. Likewise, information from the site characterization report may be useful in tailoring the screening to the specific situation. Even if the available information is insufficient to make a tentative identification at the grossest level (i.e., chemical or microbiological), it still may be of value during application of the screening.

The first step of the process shown in Figure 4-4 is an evaluation of available information from the current threat that might provide clues about the identity of the suspected contaminant. Information that should be considered in developing an analytical approach for a specific contamination threat includes the following:

- **Public health information** may be available if exposed individuals seek medical attention, and the clinical data for these patients may provide insight regarding the identity of the contaminant. Such information may be used to make a tentative identification of the contaminant or contaminant class, and in some cases might provide definitive identification. It is important to note that even though exposure has occurred, it does not necessarily imply that drinking water is the source of the contamination; other routes of exposure, such as food, air, or surfaces might be considered depending on the situation.

- **Tentatively positive results** from field testing may be used to tentatively identify a specific contaminant or contaminant class. Negative results may be used to exclude certain contaminants from further consideration. The credibility of the field test results **must** be evaluated in the context of the reliability of the field test equipment and procedures.

- **Physical evidence** at the site may provide insight regarding the identity of the contaminant. For example, empty containers might have markings indicating the nature of the contaminant, and analysis of the residual material in the container may confirm the identity of the substance. Other physical evidence from the site, such as dead animals or plants, might be used to formulate a hypothesis about the identity of the substance, and thus inform the analytical approach.

- **Information about a specific contaminant** from a database or fact sheets may be used to make a tentative identification of the suspect contaminant. For example, field screening results and/or physical evidence might be used in conjunction with detailed information about potential contaminants to make a tentative identification of the contaminant or contaminant class.

- **Location-specific contamination threats** should also be considered during development of an analytical approach for a specific contamination threat. For example, utilities may have

identified potential contaminant sources (e.g., chemical warehouses) during their vulnerability assessment, and such opportunity contaminants might be explicitly included in the analytical approach.

- **Background concentrations of the specific contaminant at the site** may be extremely important in determining if a contamination incident has occurred. In some cases and for some contaminants, background levels may be at detectable concentrations. **If unrecognized, background concentration of a contaminant may be confused with an actual contamination incident.**

- **Threat credibility** may provide an indication of the severity of the incident, and thus may indirectly impact the analytical approach. For example, if a threat is deemed highly credible, then complete screening for both chemical and biological contaminants might serve as the analytical approach regardless of other information collected from the site.

- **Consequences** of failing to properly identify an unknown contaminant (or not confirming the absence of harmful contaminants) should also be considered in developing an analytical approach. The higher the potential consequences of a misdiagnosis of the incident, the more rigorous the analytical approach should be.

5.3 Overview of Analytical Approach For Unknowns

In the case of a complete unknown, the problem of confirming the presence/absence of a contaminant or identifying and quantifying a specific contaminant presents a significant challenge. The difficulty arises from the large number of potential contaminants of concern, and the impracticality of screening for them all. To address this issue, the analytical approach for unknowns was based on contaminant classes derived from a prioritization of chemicals and pathogens of public health concern if present in the drinking water supply. The approach used to prioritize potential contaminants is briefly discussed in Section 2.1 of Module 1.

The analytical approach for unknown contaminants in water presented in this module is comprehensive for selected, *priority contaminants* and provides coverage for hundreds of additional contaminants not on this list. The following assumptions and principles were used in the development of these approaches:

- Selection of target analytes was based on an assessment of contaminants likely to pose a threat to **public health** if introduced into the drinking water supply.
- Existing laboratory infrastructure and analytical methodologies were utilized when possible.
- Both chemical and microbiological procedures are tiered, with a progression through field safety screening and rapid field testing to laboratory testing to confirmatory analysis.
- Samples analyzed in a laboratory that cannot be confirmed by the laboratory performing the test are referred to laboratories that can perform a confirmatory analysis. This upward referral system is formalized for microbiological analysis, through the Laboratory Response Network, while it is not as well defined for chemical analysis.
- The entire approach relies on the systematic elimination of potential contaminants, both to ensure the safety of sampling and laboratory personnel, and to aid in identification of the unknown contaminant.

Considering the principles and assumptions upon which the comprehensive analytical approach is founded, it is likely that the approach may evolve as new methodologies are developed and refined. Furthermore, laboratories with advanced capabilities may wish to implement alternative procedures that either expand coverage or streamline the analysis. Such modifications would be acceptable assuming that they provide at least equivalent coverage of target analytes compared to the standard approach and meet the data quality objectives of the analysis, such as legal defensibility of data. The comprehensive analytical approach in this module should serve as a baseline against which any alternate approach should be compared.

It is also important to realize that identification of unknown contaminants in water samples is not an exact science. There should be no expectation than any combination of technology and analytical personnel will guarantee successful identification of unknown contaminants. However, application of appropriate technologies and training of laboratory personnel will likely increase the probability of success. The successful identification of an unknown is dependent upon the skill of the laboratory personnel and the laboratory having appropriate analytical technology. With the many types of analytical techniques and methods in existence, it is likely that no one analyst, no matter how skilled, can use all these techniques and methods. A more thorough identification of unknown contaminants may involve a team of chemists and microbiologists to provide consultation and/or perform various analyses.

Since the procedures and laboratories used for the analysis of chemical and microbiological contaminants are significantly different, discrete analytical screening procedures have been developed for each. The screening for chemical contaminants is presented in Section 6, while the screening for microbiological contaminants is presented in Section 8. These procedures are briefly discussed in the following subsections.

Not only may different laboratories be involved in the analysis of chemical and microbiological contaminants, but some select analyses or extreme hazards should be handled only by a limited number of specialized laboratories. Since different laboratories may be involved in implementation of the analytical approach for a specific water contamination threat, communication and coordination among the various laboratory personnel involved in the analysis of an unknown sample is critical. For example, other laboratories should be made aware of potentially harmful contaminants revealed by other laboratories. This may be vital to the safety of the laboratory personnel as well as the expeditious identification of unknowns.

5.3.1 Screening for Chemicals, Including “Unknowns”

Screening for chemicals, including “unknowns,” is described in detail in Section 6. Because the target audience for Section 6 is laboratories, the following overview is presented for the benefit of planners and managers. In summary, the chemical screen integrates several analytical techniques to cover a broad range of chemical classes. These analytical techniques include not only wet chemistry and instrumental analysis, with which laboratories are typically familiar, but also various hand-held equipment and commercially available test kits, such as those based on immunoassays.

The overall screen is broken up into two parts, one referred to as a *basic screen* and the other as an *expanded screen*. The suite of techniques utilized in the expanded chemical screen is comprehensive for all prioritized contaminants of concern discussed in Section 6.1.1. Furthermore, the screen may be capable of detecting hundreds of additional chemicals that were not identified as high priority, but

could still pose some problem if used in an intentional contamination threat or incident. It is important to note that the screens are not prescriptive and labs have a great deal of flexibility in building an analytical approach that is consistent with their existing capabilities and experience while meeting the needs of their clients. However, it is strongly recommended that screening for chemicals encompass a wide range of possible contaminants given the large number of chemicals potentially available. See Section 6.1 for more details.

The *basic screen* utilizes *established analytical techniques* in conjunction with legally defensible, *standardized methods* for the analysis of contaminants in water. However, these established techniques do not provide complete coverage for all target analytes. For instance, currently there are no standardized methods for analysis of the biotoxins of concern in water. To address these gaps, exploratory techniques, which do not have standardized methods, are used in the *expanded screen*. For instance, immunoassays or liquid chromatography-mass spectrometry may be incorporated into the expanded screen to cover biotoxins. Of the many analytical techniques available, the ones utilized in the expanded screen are those that may show the most promise for water analysis. Particularly, those that have established applications in media other than water provide a basis for inclusion in the expanded screen.

In the screening procedure, analysis of contaminants is divided into chemical classes, such as organic, inorganic, and radionuclides:

- Organic analyses utilized in this approach are comprised of some combination of the following three steps: 1) extraction or recovery of the contaminant from the aqueous matrix, 2) separation of the compounds through gas chromatography or liquid chromatography; and/or 3) detection and identification of the analyte. Preparatory and extraction techniques for organic constituents should be broad enough to recover a variety of compound classes (e.g., a range of hydrophilic properties and molecular weights). A variety of techniques are used for detection of organic constituents. When mass spectrometry is used for detection, qualitative identification may be realized through electron ionization mass spectral library comparisons.
- The inorganic analyses include several analytical techniques: classical wet chemistry and instrumental techniques such as inductively coupled plasma mass spectrometry, inductively coupled atomic emission spectrometry, atomic absorption spectrometry for trace metals, and ion chromatography for anionic and cationic contaminants.
- The analysis of radionuclides during an emergency incident relies on conventional radiological techniques, but falls into a separate paradigm than other chemicals because radionuclides may be characterized by both the type of radioactivity they emit as well as specific radioisotopes.

Figure 4-4 illustrates an important issue in the screening for unknown chemicals, namely that confirmatory analysis may be required in the case of a tentatively identified chemical. In general, a positive result from a rapid field test or safety screening (performed in the field or laboratory) would be considered tentative identification and require independent confirmation. By contrast, chemicals identified through the application of standardized methods typically do not require independent analytical confirmation because recommended confirmatory steps are often incorporated into the methods themselves. In some cases, another laboratory with specialized capability may need to perform the confirmatory analysis. For instance, confirmatory analyses for chemical weapons would be performed only in few established laboratories designed and permitted to work with these substances.

When possible, confirmatory analyses should be performed using existing standardized methods accepted for analysis of the target analyte in a water matrix. When a standardized method is unavailable, confirmatory analysis may need to be performed through application of methods that rely upon different separation and/or detection techniques as a means of independently verifying the identity of a chemical contaminant.

5.3.2 Screening for Microbiologicals, Including "Unknowns"

The microbiological screen is designed to recover several classes of organisms, including parasites, bacteria, and viruses. Furthermore, the approach may recover some high molecular weight biotoxins, such as botulinum toxins. The four basic steps of the microbiological screen include: 1) concentration and recovery in the field; 2) rapid field testing; 3) testing at a Sentinel laboratory; and, if needed, 4) testing at a Reference laboratory.

To obtain the detection limits necessary to provide results from microbiological analysis that are meaningful from a public health perspective, it is often necessary to concentrate the water sample by several orders of magnitude (e.g., 100 liters concentrated to 100 milliliters). In the microbiological screen (Section 8), concentration is performed by *ultrafiltration*, a physical separation process capable of complete retention of parasites, bacteria, viruses, and potentially some large molecular weight biotoxins. Ultrafiltration is capable of processing large volumes of finished water in a short period of time, while continuously concentrating pathogens and other suspended solids in the retentate. The accumulated material is then removed from the membrane through mechanical or chemical means and collected as a retentate. This low volume retentate may be then subjected to microbiological analysis, so it should be handled with appropriate caution to ensure the safety of the sampler and the viability of any organisms collected.

The rationale for performing this concentration step in the field as an integral part of sample collection is based on two considerations. First, containers approved for the shipment of large volumes of liquid suspected of containing select pathogens do not exist; thus there may be no effective means of quickly transferring a large water sample to another facility for processing. Second, concentration of microbiological contaminants in the field allows for the useful application of field screening devices (e.g., pathogen field test kits), the next step of the microbiological screen.

After concentration, the concentrated sample is divided into three aliquots. Two of these aliquots are packaged for shipment to the laboratory, while the third may be used for field testing. The method for field testing will depend on the technology utilized, but in the case of pathogen field test kits, a small volume of the concentrate may be directly applied to the pathogen field test kit, followed by a short reaction period and evaluation of the test result. A positive result should be considered tentative, and the information used accordingly in the context of the overall threat evaluation.

The remaining two aliquots are sent to a laboratory, such as an LRN Sentinel Lab, capable of performing tests for tentative identification of target pathogens. One aliquot may be used to perform culture techniques for the target pathogens. If the initial results of the culture method are analyzed, and colonies of a particular morphology are considered tentatively positive, they are forwarded to an LRN Reference laboratory. The second aliquot may be used for PCR and subsequent molecular analysis for target pathogens, which will provide more rapid, yet still tentative, results compared to the culture technique. However, molecular assays do not necessarily produce specimens that can be forwarded on to LRN Reference laboratories for confirmatory analysis. It is important to note that

LRN PCR techniques for select agents may not be performed by Sentinel labs, although Sentinel labs can perform certain non-LRN PCR techniques.

Upon tentative identification of a target pathogen, the suspect cultures are isolated and processed for referral to higher level LRN laboratories capable of confirming the presence of select pathogens through a combination of culture and PCR techniques. Once the sample enters this level of the LRN, the existing network, and methodologies will be utilized to further characterize the pathogen.

6 Analytical Approach for Chemical Contaminants

6.1 Overview of Contaminant Issues

6.1.1 Types of Chemical Contaminants Covered by the Analytical Approach

Module 1 of this Toolbox provides an overview of the nature of intentional contamination threats that drinking water facilities might face. Water from the drinking water distribution systems is considered the most significant vulnerability, as opposed to raw source water or wastewater. The focus of the analytical approach in this section is on approximately 35 **specific** contaminants, selected from a list of chemicals, biotoxins, and radionuclides, prioritized based on the contaminant's potential threat to public health from a national perspective (see Module 1). **General** water quality parameters from distribution systems (pH, turbidity, chlorine residual, total organic carbon, etc.) are discussed in terms of site characterization (Module 3, Table 3-2). These general water quality parameters are potential indicators of chemical contamination at best, and may not cover all of the contaminants of concern.

The approximately 35 specific contaminants are not necessarily listed in this module or in Table 1-1 of Module 1. There are several reasons for this. First, it may not be advisable to specifically list these, since such information could be used with malicious intent. Second, a particular contaminant may be very important in a particular locality, but not have been included on the national priority list. Third, as part of fulfilling the goal of due diligence in providing a comprehensive screen (Section 1.2.2), it is necessary to include other chemicals in the analytical approach that encompass a broad range of effects, not just those that may have the highest public health impact.

The approach taken in this module is to divide potential contaminants into classes based on their analytical grouping (i.e., how contaminants with similar properties are analytically determined). This helps to limit the number of methods to those that encompass the largest number of analytes. The chemical types, resulting analytical groups, and examples of specific contaminants, are shown in Table 4-1. Suitable analytical methods are discussed further in Sections 6.4 and 6.5.

Table 4-1. Summary of Types of Chemical Contaminants, their Analytical Group, and the Class of Contaminants Determined by the Analysis

Chemical types	Analytical Group	Example Contaminants*
Organic	Volatiles	Acetone, acrylonitrile, chloroform, methyl *t*-butyl ether, tetrachloroethene, toluene,
	Semivolatiles	Organophosphates (e.g., malathion, mevinphos, dichlorvos, etc.), cyanazine, chlorinated insecticides, chlordane, pentachlorophenol
	Non-volatiles	Sodium trifluroacetates, surfactants
	Carbamate compounds	Aldicarb, carbofuran, oxamyl
	Quaternary nitrogen compounds	Diquat, paraquat
	Pharmaceuticals	Nicotine, illicit drugs
Inorganic	Trace metals	Mercury, lead, cobalt
	Nonmetals	Arsenic salts
	Organometallics	Organomercury compounds
Cyanides	Cyanides	Cyanide salts, cyanogen chloride
Radionuclides	Radiologicals	Cesium-137, Cobalt-60, Strontium-92
CW Agents	Schedule 1 only**	(e.g., VX, sarin, nitrogen and sulfur mustards, Lewsites)

* Not every contaminant in a particular analytical group is listed in this column.
**See Section 2.1.4 for a discussion of Schedule 1 agents.

6.1.2 Selection of Appropriate Methods for Contaminant Analysis

As described in Section 5 of this module, there are two general approaches to the chemical screen. One approach is referred to as the "basic" screen, while the other is referred to as the "expanded" screen. Together, they are a comprehensive screen for the 35 priority contaminants and also provide coverage for hundreds of other potential water contaminants, although it is not feasible (or necessary) to determine all of the hundreds of thousands of chemicals in existence. Fewer laboratories may be capable of implementing the expanded screen (Section 6.5).

It must be emphasized that this module along with Sections 6 and 8 are **not** intended to represent a prescriptive "how-to" laboratory manual. Rather, the model screening procedure (Sections 6.3-6.5, 8.1) is intended to be a planning tool for laboratories to formulate a laboratory guide specific to their needs and capabilities. For instance, the basic screen presented in Section 6.4 is composed of relatively reliable and accessible techniques, which hopefully will encourage more laboratories to develop some screening capability for potential harmful chemical contaminants (i.e., beyond regulatory requirements). However, planners may not wish to employ any elements of the basic screen, but rather rely only on techniques used in the expanded screen (Section 6.5), backed up by suitable analytical confirmation to ensure defensibility of the results. Planners must exercise due diligence in planning their analytical approach, as well as all other response activities, to protect public health and safeguard the water supply.

For the selection of appropriate methods to include in the screen, it is important to realize that planning is a vital part of site-specific response to a contamination incident. In many cases, planning for the site characterization (Module 3) will drive the selection of methods. In some cases, it may be desired only to identify the contaminant, but accurate quantification may be necessary in others. Depending on the specific plan, various goals and analytical methods may be applicable.

An intentional contamination incident may produce contaminant concentrations ranging from extremely high (milligrams per liter), when much contaminant is added to a relatively small amount of water, to very low (low to mid microgram per liter), as in the tail of a transient contaminant slug in a drinking water distribution pipe. Accordingly, the analytical methods described in this approach were selected to be conservative and reflect the goal of defensibly determining lower concentrations of chemicals. This great variability in analytical needs that may arise in each threat/incident is another reason that this section is not a prescriptive "how-to" manual.

6.1.3 Initial Processing of Contaminants prior to Laboratory Analysis

Regardless of the type of screening that the laboratory uses, it is likely that laboratories will receive samples that have been characterized to some extent, and perhaps tentatively identified, at the site. Figure 4-5 indicates the types of laboratories that might analyze emergency water samples. The site hazard assessment performed during site characterization will help the water utility emergency response manager (or the designated incident commander) decide which laboratories to use for a particular sample set. If a chemical contaminant has been tentatively identified in the field, it may aid in the selection of an appropriate laboratory. It will be necessary to then apply specific analytical techniques to confirm its identity and/or quantify the concentration. Otherwise, the sample may be subjected to a screening procedure, which is described in more detail below. Note that the screening procedure box does not explicitly list radionuclides, since radionuclide analysis involves a different paradigm, as discussed in Section 6.4.8, below. Also, some radionuclide screening is performed upon receipt by the laboratory as discussed in Section 3, in addition to the field screening in Section 4.

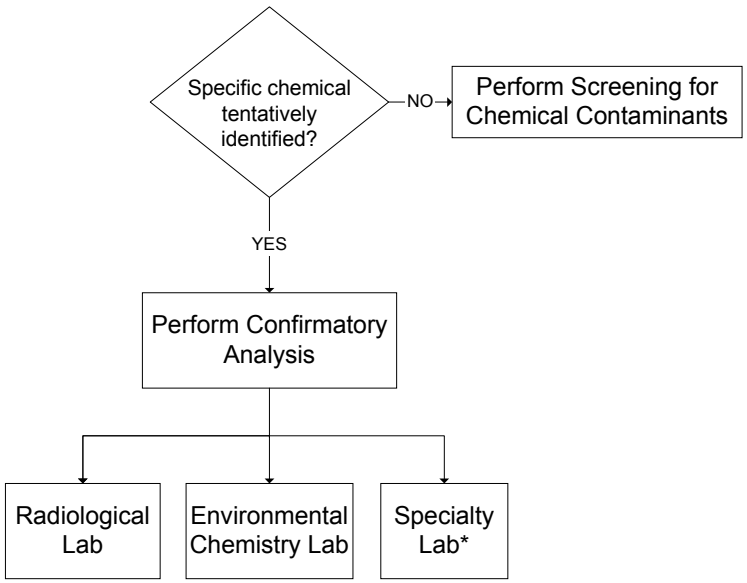


Figure 4-5. Initial Analytical Approach to Processing Samples with Chemical Contaminants
**Specialty labs include the LRN and those only accessible through law enforcement (e.g., CW labs).*

At the starting point for Figure 4-5, the contaminant identity is hypothesized based on available information from the site characterization report. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; tentatively positive results for a specific contaminant during field safety screening or rapid field testing; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the disease-causing contaminant.

It is important to note, however, that each of these situations has a different level of credibility for the purpose of tentative identification (Module 2) and that additional contaminants may be present. In general, tentative identification may focus the analytical approach on the specific contaminant subclass, leading to confirmatory analysis for the particular contaminant. For example, tentative identification of a class of pesticides (e.g., organophosphates) may be based on results from a test kit, and this information might be used to focus the analytical approach on specific pesticides within that class.

In most cases, it is anticipated that a specific chemical contaminant will not be identified with sufficient reliability to be considered tentatively identified, and it will be necessary to conduct screening for potential chemical contaminants. Depending on the strength of the tentative identification, it may be wise to consider heading down both paths of Figure 4-5 simultaneously. If the evidence for tentative identification is sufficiently strong, and if there are no other contaminants suspected, then screening may be delayed. Otherwise, screening should begin simultaneously with the confirmatory analysis, as described in the Section below. At the other extreme, during a 'confirmed' incident, the contaminant will likely be known, and the point of analysis in this case is to further characterize the contaminated area to support the planning stage of remediation and recovery.

6.2 Confirmatory analysis

It is necessary to confirm the identity and/or concentration of a contaminant identified either in the field or in the laboratory. In the case of a tentatively identified chemical contaminant, Figure 4-5 indicates that one of several types of distinct, specialized laboratories might be involved in conducting confirmatory analysis. The functions of these laboratories are described in more detail in Section 2.1 as part of the infrastructure discussion. Some confirmatory analysis may only take place in specialty laboratories, such as those for Schedule 1 CW agents. A discussion of these techniques and the associated equipment is beyond the scope of this document since these laboratories presumably have established procedures for these specialty analytes, and an overview of these techniques would not be particularly helpful to the target audience for this document. In addition, access to these laboratories is restricted and must be made by the appropriate authorities.

For radionuclides, analytical confirmation may be viewed differently than most chemicals because radionuclide analysis can take the form of screens for gross alpha, beta, or gamma radiation, and/or it can take the form of analysis for the specific radionuclides themselves, such as strontium-90. Thus, analytical confirmation may involve the process of confirming quantity of gross radiation or identifying the radionuclide. The type of analysis that is performed will be based on the analytical goals. For example, radionuclides in drinking water regulation are often characterized by their gross alpha and gross beta emissions. For the purpose of emergency analysis of water contaminants, a tiered approach is suggested, with screening for gross radiation in the field or upon receipt by the laboratory followed by identification of the radionuclide, which may be important for a more complete understanding of risks to public health as well as potential criminal actions against perpetrators.

On the other hand, many environmental chemistry laboratories can confirm a significant number of chemical contaminants through the use of a variety of standardized methods. In the context of this module, standardized methods are produced as a standard by a recognized method development organization (EPA, ASTM, AOAC, ISO, etc.) and contain valid steps to defensibly confirm the presence and/or quantity of specific contaminants. For the analysis of emergency water samples, a standardized method need not be promulgated for compliance monitoring of drinking water samples.

Environmental chemistry laboratories are often familiar with promulgated, standardized methods and may have the equipment and expertise to perform confirmatory analysis using such standardized methods. A number of standardized methods are published by various organizations, and may be selected from an appropriate method database, such as the National Environmental Methods Index (NEMI, http://www.nemi.gov). NEMI contains methods reviewed and selected by the National Methods and Data Comparability Board (http://wi.water.usgs.gov/pmethods/), a partnership of water-quality experts from Federal agencies, States, Tribes, municipalities, industry, and private organizations. The Board provides a framework and forum for comparing, evaluating, and promoting monitoring approaches for water quality. Methods are available in NEMI to support the analytical approach for the priority chemical contaminants, and a laboratory can use the NEMI database to select a confirmatory method for a particular chemical contaminant based on its particular expertise and equipment. NEMI is searchable by analyte, and a search will often return several methods for the same analyte, developed to meet a variety of needs. For example, some methods are EPA drinking water methods, some are EPA SW-846 methods, and some were developed by USGS or DOE for their environmental monitoring programs, etc.

Although consulting NEMI first is recommended, there are other sources of standardized methods, some of which are shown in Table 4-2. There are other comparable standardized methods available from standards setting organizations like ASTM (http://www.astm.org), AOAC (http://www.aoac.org),

and ISO (http://www.iso.org/). In choosing a method, keep in mind that some of these standardized methods may be prescribed for a specific intended purpose, such as drinking water compliance monitoring. However, in the context of this module, the methods are **not** prescribed, because there is no regulatory driver for doing so. Rather, all of these methods resources are to be used as **planning tools** to assist laboratories in selecting methods for use in implementing the analytical approach presented in this module **prior** to analyzing actual emergency water samples. For many laboratories, planning may be simplified through the use of methods they are already familiar with, such as EPA drinking water and SW-846 methods.

Table 4-2. Sources of Standardized Methods

Name	Description	Publisher	How to obtain
National Environmental Methods Index (NEMI)	Contains methods compiled from many sources. **May be consulted first.**	US EPA and USGS	http://www.nemi.gov
Recently developed US EPA methods	Contains current revisions of promulgated methods for drinking water analysis with notes	US EPA Office of Water US EPA Office of Research and Development (ORD)	http://www.epa.gov/safewater/methods/sourcalt.html http://www.epa.gov/nerlcwww/ordmeth.htm
EPA SW-846 methods	Mainly for solid waste, but many are applicable for drinking water, using appropriate preparation techniques.	US EPA Office of Solid Waste	http://www.epa.gov/epaoswer/hazwaste/test/main.htm
EPA drinking water manuals	Printed versions of drinking water methods	US EPA ORD	For ordering details, see http://www.epa.gov/nerlcwww/methmans.html
40 CFR Parts 136 and 141	Promulgated list of defensible methods widely accepted in the analytical community for water and wastewater.		http://www.epa.gov/docs/epacfr40/chapt-I.info/subch-D.htm
Standard Methods for the Examination of Water and Wastewater, 20th edition (January 1999)	Various methods covering the range of water analytes.	American Public Health Association and American Water Works Association	Available from most booksellers. ISBN: 0875532357
Other recognized method development organizations	May provide comparable methods	AOAC ASTM ISO others	http://www.astm.org http://www.aoac.org http://www.iso.org/

If standardized methods are not available for the contaminant of interest, then analytical confirmation may involve the techniques described below for basic and/or expanded screening (Sections 6.3 and 6.4). In this situation, the requirements for analytical confirmation are generally not well defined and are further complicated by the issue of legal defensibility of scientific data. Section 3.5 of this module provides an overview of rules that govern the admissibility of scientific evidence into a court of law and points out the pitfalls associated with using methods that have not been standardized. There are currently efforts underway in the forensic community to resolve these issues and develop standard approaches for the analysis (including confirmation) of samples contaminated with an unknown substance. While guidance from the forensic community is not available at this time, it may be included in future versions of this module. Ultimately, it may be the responsibility of laboratories to take appropriate steps to support the admissibility of data produced using exploratory techniques that have not yet been widely accepted in the scientific community (see Section 3.5).

6.3 Laboratory Analytical Screening for Chemical Contaminants, Including "Unknowns"

The *laboratory analytical screening* described here is **different and separate** from the laboratory safety screening (Section 3.1.4 of this Module) and the field safety screening and rapid field testing (briefly described in Section 4 of this Module and more completely in Module 3). Briefly, the field safety screening and rapid field testing were performed during characterization of the contamination site, before any laboratory work is performed. The entire site characterization process is designed to reduce risk to the site characterization team and any individuals coming into contact with samples collected from the site. Site characterization activities are not limited to only field safety screening and rapid water testing, which may only capture a few contaminants, but also include a site investigation that may identify other signs of hazards. These activities aid in the site hazard assessment and help ensure that samples are sent to a laboratory prepared to deal with both the analysis and any safety issues. For example, if pathogens are suspected, the samples should not be sent to an environmental chemistry lab.

The overall concept of laboratory analytical screening for an unknown chemical in a water sample is presented in Figure 4-6. This chemical screen consists of two core elements: 1) application of multiple analytical techniques to screen for a wide range of analytes; and 2) analytical confirmation of tentative results. In the first core element, the combination of analytical techniques used to achieve broad coverage of the contaminant classes of concern includes both standardized methods and exploratory techniques. The standardized methods are derived from those same sources as listed in Section 6.2. Exploratory techniques are those that do not necessarily form the basis of standardized methods for water analysis, but are capable of detecting chemicals that are not included in existing standardized methods. Both of these elements are implemented in the laboratory.

Two different chemical screens were constructed from the established and exploratory techniques. The first, indicated in Figure 4-6 as the "Basic Screen," (Section 6.4) uses only standardized methods, and the method analytes include a significant percentage of the priority chemical contaminants as well as many other chemicals. The second, referred to as the "Expanded Screen," (Section 6.5) combines established techniques and exploratory techniques to achieve the broadest coverage, including all priority chemical contaminants. Additionally, the Expanded Screen provides laboratories with additional options regarding the instrumentation used to implement both established and exploratory techniques; however, the results may not be as definitive as those for established techniques.

The second core element in Figure 4-6 is analytical confirmation of the results. As shown in the figure, some methods utilized in the "Basic" screen contain required steps for defensible confirmation. Some do not, and other confirmatory analysis should be performed, as described in Section 6.2. As shown in Figure 4-6, it also would be necessary to confirm the results of most exploratory techniques, unless the technique is applied within a methodology that utilizes suitable validation procedures. The strategy of using the variety of techniques in the "Expanded Screen" may lend itself to fulfilling the requirements discussed in Section 6.2 for confirming an analyte, particularly one for which no standard method exists. For example, analytical confirmation may sometimes be accomplished through determination of the contaminant by two or more analytical techniques that operate on independent principles (e.g., LC/UV and GC/MS). In comparison, analytical techniques that operate on the same principles (e.g., different immunoassays) may be unreliable for confirmation purposes and should be used with caution.

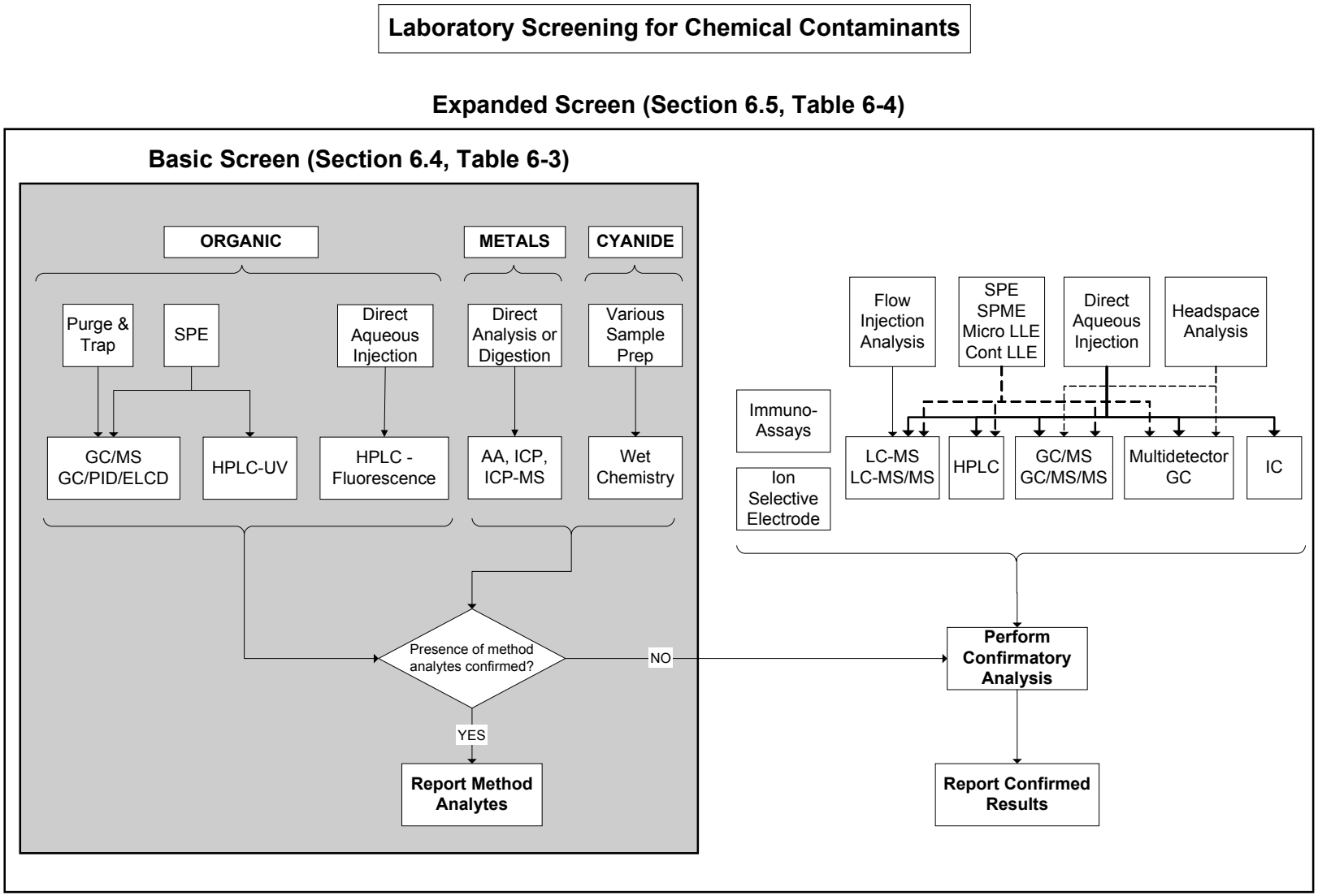


Figure 4-6. Overview of Screening and Confirmatory Analyses for Chemical Contaminants

6.4 Basic Screening using Established Techniques with Standardized Methods for Target Analytes

The basic screen is designed to capture many of the chemical contaminants of concern using a relatively small number of well-defined analytical techniques. The techniques chosen for this basic screening analysis are summarized in Table 4-3. This is to say, if the methods in Table 4-3 are performed, then the screen may cover a large percentage of the priority chemical contaminants (Table 4-1). Furthermore, many other contaminants of concern, but of lower priority, may be screened for as well. To increase confidence in the results, only standardized methods (e.g., EPA drinking water, SW-846, or comparable methods) are used for the basic screen. Comparability involves analytes determined, detection limits, QA/QC, etc. See Section 6.2 for information about comparable methods.

As discussed previously, EPA standardized methods are suggested mainly because many labs may be familiar with some or all of these methods, and many laboratories are certified and/or accredited to determine water contaminants using these methods. This increases the defensibility of the results, since the laboratories would have experience in performing all of the required QC within acceptable ranges. Also, in most cases, the use of EPA methods also means that if a method analyte is determined by these methods, no further analytical confirmation would be necessary since many of these methods contain confirmatory steps. In choosing a method, keep in mind that some of these standardized methods may be prescribed for a specific intended purpose, such as drinking water compliance monitoring. However, in the context of this module, the methods are not prescribed, because there is no regulatory driver for doing so.

The basic screen may serve as a springboard for more complete characterization of the sample, in an "outside-the-box" manner. Namely, a significant advantage to using the techniques in the Table 4-2, or comparable ones, is that many rely on chromatography and/or mass spectrometry, so the data should be capable of being evaluated for the presence of not only target analytes, but also other compounds. If a contaminant is discovered that is not in the analyte list of the method used, the identification should be considered tentative until confirmed (Section 6.2). In the absent of confirmation, expanded screening of the sample should be applied (Section 6.5).

Information from the basic screen may also be used to inform the selection of exploratory techniques. For instance, if a target analyte or unknown peak is not found in a Method 524.2 analysis, the compound is likely not a volatile organic; if no peak is present in a Method 8270D analysis, the unknown may be inorganic in nature or thermally unstable.

Table 4-3. Suggested Analytical Techniques for Performing the Basic Chemical Screen, broken out by the classes given in Table 4-1.

Chemical (general class)	Analytical Technique	EPA Method[1]	Analyte List[4]
Volatiles (organic)	Purge-and-trap PID/ELCD Purge-and-trap GC/MS	502.2, 8021B 524.2, 8260B	A
Semivolatiles (organic, includes many pesticides)	Solid-phase extraction GC/MS	525.2, 8270D/3535A	B
Carbamate pesticides (organic)	HPLC – fluorescence detection	531.1, 531.2	C
Quaternary nitrogen compounds (organic)	HPLC – UV	549.2	D
Trace metals (inorganic)	ICP-AES, ICP-MS, graphite furnace AA	200.7, 200.8,[2] 200.9	E
Total mercury (inorganic, includes organomercury compounds)	Cold vapor AA	245.1, 245.2 with persulfate	F
Cyanides	Wet chemistry	335.2, 335.3, 335.4	G
Radionuclides	Gross alpha, gross beta, Gross gamma	900, or technique preferred by lab[3]	H

1. Method titles are listed in Table 4-19 in the appendix (Section 10)
2. Method 200.8 may be applied in the time-saving "direct analysis" mode that does not require digestion, if the NTU of the water sample is <1. Note that the NTU of the water may be quickly determined in-house and/or may be available in the site characterization report supplied with the sample. The use of the scanning mode in Method 200.8 is also suggested.
3. Many radionuclide laboratories have developed in-house methods for rapid screening of radionuclides. These may be similar to EPA 900-Series methods, which were developed for the measurement of very low, environmental levels of radioactivity in drinking water but may require several days to obtain a result. See Section 6.4.8 for further discussion. Analytical confirmation may be required via EPA Method or other defensible methods.
4. Standard may contain these. See Table 4-20 in the appendix (Section 10).

As mentioned in Section 1, this module is primarily intended for the purpose of planning an analytical response. The users may wish to develop their own basic screen after evaluation of their particular capabilities and experience as well as the needs and concerns of their clients. (**Some hypothetical examples of basic screens are given in Section 7 of this module.**) For a utility laboratory, the basic screen would be based on the utility's perception and knowledge about threats in their area and the capabilities of their laboratories. Because there is no regulatory requirement to apply any basic screen, a laboratory may, in principle, choose not to employ any of the standardized methods in Table 4-3. In this case, however, it would be prudent from a public health perspective to employ an expanded screen based on exploratory techniques capable of determining the analytes of interest, such as those listed in Table 4-20.

There are several important notes about Table 4-3:

- Screening of radionuclides involves a different paradigm than conventional chemicals. See Section 6.4.8 for details.
- The preparation method for 8270D listed is 3535A, based on solid-phase extraction. Separatory funnel preparation for 8270D, or any other separatory funnel method, is not included because separatory funnels may release aerosols when vented, potentially increasing the risk of exposure for laboratory personnel, unless appropriate hoods and/or other control measures are employed. Granted, separatory funnel techniques are safely used every day but, considering that other sample preparation methods (such as 3535A)

sorbent tube is heated and backflushed with helium to desorb the trapped sample components into a capillary gas chromatography (GC) column interfaced to a mass spectrometer (MS). The column is temperature-programmed to facilitate the separation of the method analytes, which are then detected with the MS. Compounds eluting from the GC column are identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a database. Reference spectra and retention times for analytes are obtained by the measurement of calibration standards under the same conditions used for samples. The instrument should be calibrated for the analytes of interest, using analytes similar to those found in Analyte List A (Table 4-20).

Some laboratories possess purge-and-trap instrumentation with a PID detector in series with an ELCD detector. This combination provides the ability to determine most of the analytes in list A. Because of the nature of the PID and ELCD detectors, however, they cannot necessarily provide the additional level of information and analytical confidence as a mass spectrometer (see Section 6.5.1 below). Accordingly, Methods 502.2 and 8021B are included primarily to increase the number of laboratories capable of this analysis.

6.4.2 Semivolatiles (Organic)

Solid-phase extraction involves the removal of analytes from water onto a solid sorbent material (based on EPA Method 525.2). Analytes, internal standards, and surrogates are extracted from a water sample by passing 1 liter of sample water through a cartridge or disk containing a solid matrix with a chemically bonded C18 organic phase (solid-phase extraction, SPE). The organic compounds are eluted from the SPE cartridge or disk with small quantities of ethyl acetate followed by methylene chloride, and this extract is concentrated further by evaporation of some of the solvent. The sample components are separated, identified, and measured by injecting an aliquot of the concentrated extract into a high resolution fused silica capillary column of a gas chromatography/mass spectrometry (GC/MS) system.

Compounds eluting from the GC column are identified by comparing their measured mass spectra and retention times to reference spectra and retention times in a database. Reference spectra and retention times for analytes are obtained by the measurement of calibration standards under the same conditions used for samples. The instrument should be calibrated for the analytes of interest, using analytes similar to those found in list B (Table 4-20).

6.4.3 Carbamate Pesticides (Organic)

EPA Methods 531.1 and 531.2 can be utilized to detect carbamate pesticides and degradation products, namely the N-methylcarbamolyoximes and N-methylcarbamates. (Note that Method 531.1 requires a different preservative.) Compared to the other EPA methods in the basic screening analysis, EPA Methods 531.1 and 531.2 do not encompass many analytes. It may be worth noting that at least one chemical (aldicarb) in this class has an immunoassay test available for screening purposes.

This immunoassay is not recognized for compliance monitoring, so it is not included in the basic screening analysis, but might be useful as a field test. In Methods 531.1 and 531.2, the water

are available, it may be prudent for laboratories to consider not using the separatory funnel preparation method.

- The methods encompass many analytes. In terms of obtaining standards to use in conjunction with the respective methods, it may be helpful to focus on certain analytes. The analytes that may be included in the standard are identified in the appendix (Table 4-20) by the list number included in Table 4-3. Laboratories may wish to add analytes to those listed in the appendix, and may already be doing so (e.g., to meet local regulation). These analytes must meet the same QC acceptance criteria and be part of the overall quality systems in the laboratory, so that the added analytes are as defensible as the method analytes.
- The methods listed in Table 4-3 determine a number of analytes that probably would not be involved in a contamination incident (in addition to those that are priority contaminants). However, for the purposes of a screen, it is valuable to include some of the additional analytes that are picked up by the method, especially since there is no way to predict which contaminants might be used in a threat or incident.
- The standardized methods listed in Table 4-3 do **not** include some analytes of concern, such as the biotoxins, chemical warfare agents, and pharmaceuticals. This may be due to the fact that since these are not regulated compounds in drinking water, there has been little impetus to develop methods for these analytes. This may change, due to the inclusion of some algal biotoxins, namely microcystins, in the Contaminant Candidate List (http://www.epa.gov/safewater/ccl/cclfs.html) and Unregulated Contaminant Monitoring Rule (http://www.epa.gov/safewater/standard/ucmr/main.html).
- The methods in Table 4-3 are not always the same ones that are required for compliance with the Safe Drinking Water Act as amended. For instance, Method 551.1, which is used for compliance monitoring of some disinfection by-products, does not encompass a sufficient number of chemicals considered as priority contaminants from an acute health effect standpoint. After all, disinfection by-products largely produce a long-term health risk, not the acute risk to human health that would be the most pressing concern during an intentional contamination threat/incident.

The following is a brief discussion of the analytical methods utilized in the Basic Screen, broken down by the chemical classes listed in Table 4-1. Many laboratories may be familiar with the individual methods listed, as these are typically the EPA drinking water compliance methods. However, the purpose of the module is not to insist that only EPA drinking water compliance methods may be used. As mentioned above, there are other fine method sources, including, but not limited to, those in Table 4-3. If these other methods are employed, they should be capable of determining the analytes of interest (i.e., Table 4-20), and they should conform to the spirit and intent of the methods described briefly below.

6.4.1 Volatiles (Organic)

Purge-and-trap concentration and analyses by GC/MS (based on EPA Method 524.2 or 8260B) may be utilized to identify organic compounds that are volatile in nature. To summarize the method, volatile organic compounds with low water solubility are extracted (purged) from the sample matrix by bubbling an inert gas through the aqueous sample. Purged sample components are trapped in a tube containing suitable sorbent materials. When purging is complete, the

sample is filtered and a 400-µL aliquot is injected into a reversed-phase HPLC column. Separation of analytes is achieved using gradient elution chromatography. After elution from the HPLC column, the analytes are hydrolyzed to form a methyl amine, which is further reacted to form a highly fluorescent derivative that is detected by a fluorescence detector. The derivatization procedure imparts specificity to the analysis, and a sample component is identified by comparison of its retention time to the retention time of a reference chromatogram. If the retention time of an unknown compound corresponds, within limits, to the retention time of a standard compound, then identification is considered positive. Because of specificity limitations of fluorescent detectors, identification requires expert judgment when sample components are not resolved chromatographically.

When peaks obviously represent more than one sample component, or any time doubt exists over the identification of a peak on a chromatogram, appropriate alternate techniques should be applied to identify the peak, such as the use of a second chromatography column, several of which are contained in the method. SW-846 Method 8321B also employs HPLC instrumentation for the analysis of carbamates, and it also describes the use of thermospray mass spectrometric detection, possibly providing additional information about the target compound. However, for technical reasons revolving around data interpretation, the thermospray interface is considered obsolete, and is in the process of being replaced (http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm).

6.4.4 Quaternary Nitrogen Compounds (Organic)

EPA Method 549.2 is a high performance liquid chromatography (HPLC) method for the determination of diquat and paraquat in drinking water sources and finished drinking water. In the method, a volume of water sample is subjected to solid-phase extraction. The eluate from the extraction device is separated through the use of liquid chromatography with UV detection. A photodiode array detector may be utilized to provide simultaneous detection and analytical confirmation of the method analytes.

6.4.5 Trace Metals (Inorganic)

a) **Inductively Coupled Plasma Mass Spectrometry (ICP-MS).** EPA Method 200.8 provides procedures for the determination of 21 elements in a single run and provides mass spectral qualitative identification with significantly better detection limits than most standard instrumental elemental analysis techniques. The method involves a sample preparation procedure with a digestion step using nitric and hydrochloric acids, although there is an alternative "direct analysis" for samples with turbidity less than 1 NTU, which is applicable to many treated drinking water samples as they typically have turbidity less than 0.3 NTU. The method describes the multi-element determination of trace elements by inductively coupled plasma mass spectrometry (ICP-MS). Sample material in solution is introduced by pneumatic nebulization into a radiofrequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a vacuum interface and detected on the basis of their mass-to-charge ratio by a mass spectrometer. The mass spectrometer may be operated in the "scanning" or the "single ion monitoring" mode. While detection limits are slightly less in the scanning mode, the use of the scanning mode offers

benefits in terms of identifying non-method analytes. Details are discussed below in Section 6.5.2a, as part of the expanded screen.

It should be noted that Method 200.8 is designed for compliance monitoring, and if acidification of the sample is not performed in the field, the method recommends that the sample be held 16 hours after acidification, prior to analysis. This may not be practical in responding to contamination incidents. (See Module 3, Section 3.2, for more details on preservation issues.) Acid addition in the field may result in the release of toxic gases, such as hydrogen cyanide, depending on the nature of the contamination. As a safeguard, sample preservation in the field should occur only after the potential presence of cyanide has been eliminated through field screening using devices such as portable colorimeters or probes. According to the procedures in Module 3, sample collection should always follow field testing (including cyanide), so this check should be automatic. If cyanide is found, the speed of reporting of Method 200.8 analytes may not be an issue since discovery of elevated cyanide levels would elevate the credibility of the threat and prompt immediate response actions, which would provide additional time for careful forensic analysis.

Because of the specificity and detection limits of ICP-MS for all the elements in Analyte List E (Table 4-20), it may be considered a superior technique for trace metal analysis. However, in the interest of more laboratories being capable of performing trace metal screening, it should be recognized that inductively coupled plasma atomic emission spectrometry and graphite furnace atomic absorption spectrometry are widely used for trace metal determination. Practitioners should be familiar with the comparative advantages and disadvantages of the techniques for trace metal determination listed in Table 4-3, particularly regarding detection limits and interferences for some of the analytes in Analyte List E (Table 4-20).

b) **Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES).** While ICP-MS is a trace elemental technique with excellent specificity and detection limits for some of the contaminants of concern, other trace elemental techniques are available in many laboratories and may be used as part of the expanded screening procedure. EPA Method 200.7 provides procedures for the determination of 32 elements in a single run through the use of ICP-AES. ICP-AES is sometimes referred to as ICAP (for inductively coupled argon plasma) or ICP-OES (for optical emission spectrometry). The instruments measure the atomic line emission spectra by optical spectrometry. The aqueous sample is acidified prior to instrument analysis. The analysis begins with a nebulization and the aerosol stream is transported to the plasma torch, which may be viewed by an optical spectrometer either head on (radially) or from the side (axially) depending on the instrument. Each orientation provides different performance characteristics, particularly in terms of interferences and detection limits, but each of these is dependent on the matrix as well as the instrument design. The speed of the analysis is also influenced by instrument design. For example, the optical system may allow either sequential or simultaneous determination of the analytes, with the simultaneous determination allowing faster analysis; it also may allow tentative identification of non-method analytes, similar to ICP-MS (above).

c) **Atomic Absorption (AA) Spectrometry.** Graphite furnace atomic absorption spectrometry (EPA Method 200.9) can also be used for a select number of metals. The acid-digested sample is

placed in the instrument and is pretreated prior to atomization. The atomization occurs after a purging with an inert gas and drying. The atomization is performed by rapid heating and produces an atomic cloud. The atomic cloud then absorbs the element-specific atomic emission from a hollow cathode lamp or electrodeless discharge lamp. Instrument design influences performance characteristics, like detection limits and number of elements that may be analyzed at one time. The atomic absorption technique may be used with other introduction techniques than graphite furnace, as shown in the next section for total mercury.

6.4.6 Total Mercury (Including Organomercury Compounds)

EPA Methods 245.1 and 245.2 allow the determination of total mercury, which includes inorganic mercury and many organomercury compounds, following digestion with potassium persulfate, which oxidizes the organomercury compound to mercuric ion before measurement. The total mercury is determined through the use of cold vapor atomic absorption. This technique greatly enhances the detection limit for mercury determination and offers other benefits as well. Total mercury may be determined as part of the trace metal analysis using methods in Table 4-3 (Section 6.4.5), except GFAA, Method 200.9. However, Methods 245.1 and 245.2, which form the basis for the dedicated mercury analysis instruments currently found in many laboratories, were included here.

6.4.7 Cyanides

Ideally, the core field testing recommended in Module 3 will detect the presence of cyanide, so laboratory analysis of cyanide would most likely serve a confirmatory role. Depending on the nature of the field test, it may use similar chemistry to the EPA Methods 335.2, 335.3, and 335.4, as described below, but typically the field test will not employ distillation. Thus, the field tests primarily detect free cyanide ion (not cyanide complexes).

It should be noted that most cyanide field tests are designed for quantitative analysis of cyanide at low levels (near the MCL), and they typically provide only a qualitative indication of the presence of high cyanide concentrations. Accordingly, it may not be necessary to perform redundant tests in the laboratory, although it may be deemed prudent to do so. Such decisions may be based on the concentration of cyanide in the water or the form of cyanide known or suspected. For instance, a titration procedure for cyanides is used when the concentrations exceed 1 mg/L (EPA Method 335.2). A reflux distillation is used to release the cyanides, which are then absorbed in a scrubber solution. The titration uses a silver nitrate solution to titrate cyanide in the presence of a silver sensitive indicator. For lesser concentrations, cyanide in water is determined through the use of colorimetry (EPA Method 335.3 and 335.4). UV digestion and distillation are used to convert the cyanides to hydrogen cyanide. Cyanides are then converted to cyanogen chloride and then subsequent reactions with pyridine and barbituric acid give a red colored complex.

The form of cyanide added to water may be important in deciding on which cyanide test is appropriate for use. Free cyanide in water may result from the addition of soluble cyanide salts or water-soluble organic cyanogenic compounds. Methods 335.2, 335.3, and 335.4 measure total cyanide, which could be a mix of free cyanide, complexed cyanide, and some organic

cyanogenic compounds. Because free cyanide is the most toxic, without knowing the concentrations of the other forms, which have widely varying toxicity, the use of the total cyanide concentration would be conservative with respect to public health implications.

6.4.8 Radionuclides

Basic screening for radionuclides represents a somewhat different paradigm than conventional chemicals because radionuclides can be characterized by both the type of radiation they emit as well as their exact chemical identity. Accordingly, initial screening for radionuclides may involve an examination of gross radioactivity. However, any initial screening that indicates the presence of a radionuclide should be followed by analytical confirmation of the chemical identity. A schematic for radionuclide screening is shown in Figure 4-7. Note that in Section 3, screening for radioactivity upon sample receipt is recommended. Accordingly, the decision point in Figure 4-7 that asks "Does lab policy require screening for radioactivity?" provides flexibility for local planning decisions.

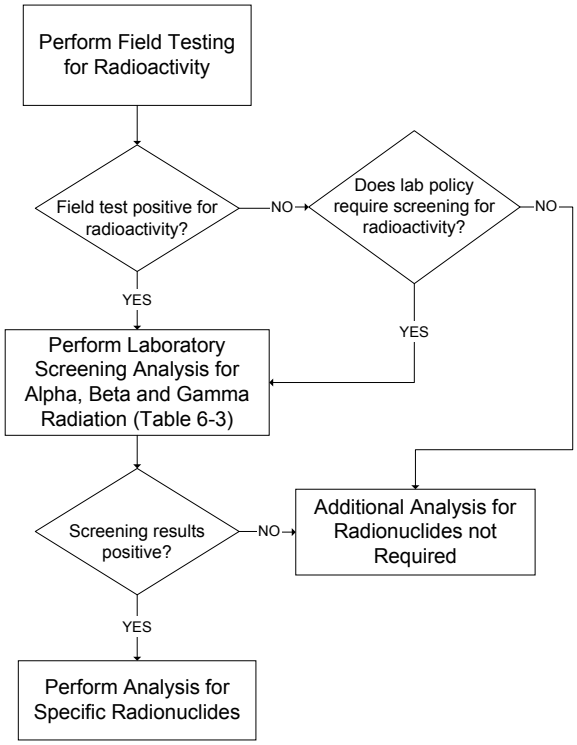


Figure 4-7. Schematic for Basic Radionuclide Screening

The results of field testing for radioactivity (Figure 4-7) must be compared to background levels to determine whether the site may have been contaminated with radioactive material. Although discussed in Module 1, it is worth noting here that EPA has developed protective action guidelines for radiation levels in water (http://www.epa.gov/radiation/docs/readytorespond/ready3.htm).

The analysis for gross alpha and beta radiation (EPA Method 900.0) may be conducted as a screening method for alpha and beta particle activities in water and used to determine if specific radiological analyses are needed. Preliminary analysis can first be conducted in the field using appropriate field portable or hand-held devices, but may be verified in the laboratory. EPA Method 900.0 can measure alpha particles with energies above 3.9 megaelectronvolts (MeV) and beta particles with energies above 0.1 MeV. In this method, the water sample is evaporated and dried, and the dried residue is counted for alpha and beta by a gas flow proportional counting system or scintillation detector system. Note that as part of their safety plan, laboratories may wish to screen samples upon arrival for gamma radiation using appropriate technologies.

If the presence of radioactive material is indicated by the initial screening, specific radioisotopes may be determined by radiochemical specific procedures, using EPA 900-Series methods or other legally defensible techniques. These procedures often involve separation of the radionuclide from the sample by precipitation procedures and subsequent determination by gas flow proportional counting system or scintillation detector system for alpha and beta emitters and an appropriate gamma detector for gamma emitters. For example, strontium-89 and strontium-90 can be measured by EPA Method 905.0. Strontium-89 and strontium-90, are precipitated as carbonates from the sample. Additional precipitation steps allow separation from other radionuclides and interferences. The daughter product of strontium-90, ytrium-90 is separated by a hydroxide precipitation step and is beta counted by a low background beta counting system. The combined strontium-89 and strontium-90 residue is also beta counted. The results for each radionuclide are determined.

Due to the unique nature of radionuclide analysis, some laboratories have developed in-house procedures for radionuclide analysis that make use of their special skills and capabilities to enhance the speed of analysis, especially since some EPA 900-Series methods are not rapid methods. For example, EPA 905.0 for radioactive strontium in drinking water recommends a two-week in-growth period for obtaining the yttrium isotope from the purified strontium. Modification of the method results in much faster results. Reduction in analysis time could be accomplished by measuring the total amount of an element's radionuclide, not the isotopic distribution. Also, for some isotopes, faster results may be obtained by simply reducing the volume of water sample processed.

In summary, many laboratories may choose to utilize a specialized method or technique for initial sample screening that may not be necessarily identical to those described in EPA 900-Series methods, although these methods must be used when reporting drinking water compliance monitoring results.

6.5 Expanded Screening using Established and/or Exploratory Techniques with Standardized or Non-standardized Methods

The purpose of the expanded screen is to capture chemical contaminants not picked up by the basic screen, namely those analytes listed in Table 4-20. The expanded screen may also detect those analytes covered by the basic screen more rapidly. It should be a sufficiently broad screen to "go fishing" for many possible contaminants. The expanded screen can be used with a combination of standardized or non-standardized methods. Note that in the case of standardized methods, no additional analytical confirmation may be required because the method used may

itself be considered definitive if applied correctly. In other cases, please see Section 6.2 for a further discussion of confirmation of analytical results.

In practice, the expanded screen can be used **in addition to** the basic screen, because the results of the basic screen may provide a "springboard" to guide the selection of techniques for the expanded screen. **Alternatively,** some laboratories may choose to utilize only the expanded screen, comprised of potentially sensitive techniques, including those summarized in Table 4-4. In the latter case, preliminary results can be cautiously used to make response decisions, but must be followed up with confirmatory analysis since screening techniques are not necessarily definitive or legally defensible.

Table 4-4. Expanded Screening for Contaminants, broken out by classes of contaminants as found in Table 4-1.

Contaminant Type	Expanded Screening Technique
Organic	GC, GC/MS, HPLC, LC/MS, Immunoassay test kits*
Inorganic	IC, AA, ICP, ICP-MS
Cyanides	Wet chemistry*
Biotoxin	Immunoassay test kits,* GC/MS, HPLC, and LC/MS
Radiological	Handheld equipment*
Chemical Warfare Agents	GC/MS with direct injection, purge & trap, and SPE/SPME, test kits,* handheld equipment*

*See Section 4.1 for important disclaimers and information about the use of these technologies. Note that when these technologies as being used in the expanded screen, they are being applied in the laboratory, not the field.

Given the variety of choices presented in Table 4-4, the question naturally arises about how to select suitable methods and equipment for the expanded screen. This section attempts to address this in a number of ways:

- Although noted in Section 6.4, it is worth repeating here that information gained during the basic screen may help guide the selection of techniques and methods for use in an expanded screen. For example, many of the techniques in the basic screen rely on chromatography and/or mass spectrometer, so the data should be capable of being evaluated for the presence of not only target analytes, but also other compounds. In addition, clues about the identity of the contaminant may be provided by the mass spectra or chromatographic retention behavior (e.g., early eluting compounds may indicate a lower boiling point, poor peak shape on a non-polar chromatography column may suggest certain (polar) functional groups, etc).

- Combining observations from multiple basic screening techniques may be helpful. For instance, if no target analyte or unknown peak is found in a Method 524.2 analysis, the unknown compound is likely not a volatile organic; if no peak is present in a Method 8270D analysis, the unknown may be inorganic in nature or thermally unstable. This reduces the possibilities, although requires knowledge of the properties of potential contaminants. Some of these many properties may be obvious to skilled analysts. One resource to help with this is the Water Contaminant Information Tool (see Module 2), currently under development.

- Many EPA standardized drinking water compliance methods are not included in Table 4-4, but may be used to implement the analysis summarized in Table 4-4 for expanded screening. This increases the number of analytes covered and, depending on the method, may **decrease** analysis time. Some standardized methods (see Section 6.2), including drinking water and SW-846 methods, may be useful to apply directly in the expanded screen, even though they are not necessarily intended for Table 4-20 analytes. In fact, by their design, SW-846 methods may allow for some "quick and dirty" approaches to screening that might be significant time savers when faced with the short turnaround times associated with the initial phases of an incident.

- A discussion of the expanded screening techniques listed in Table 4-4 is provided below, along with some appropriate **precautionary** notes. Many readers will recognize some of these precautionary notes as being components of standardized methods. The discussion below should not be considered an exhaustive technical discussion on the subject of analysis of unknowns, but is intended to be an overview of those that are more widely used, or highly promoted. Thus, this information is primarily intended for planners and some laboratories, in terms of investing in resources and techniques that may be very useful for expanding the screening capability to look for unknown chemicals. Skilled analysts may wish to pursue other sources, such as technical books, scientific journals, and peer-interaction, for detailed insight and application of these techniques to specific technical challenges.

6.5.1 Expanded Screening for Organic Chemicals

Contaminants are often extracted from water samples to facilitate the analysis (e.g., to obtain a suitable amount of contaminant for analysis). Regardless of the detector system employed, there are a few widely used sample preparation techniques. Following sample preparation, a variety of detection techniques are used to analyze the sample. Figure 4-6 illustrates which preparation techniques are commonly used with which detection techniques.

<u>Sample Preparation</u>

NOTE: Large Volume Liquid/Liquid Extraction (LLE) generally may not be recommended for aerosolizable samples. This technique, although utilized in some EPA methods, requires operation of separatory funnels that may release aerosols when vented. The generation of these aerosols may represent a larger health hazard than other techniques, unless laboratories take precautions, such as appropriate hoods and sampling handling techniques. Many of the same goals of large volume liquid/liquid extraction may be accomplished through the use of the techniques described below. The techniques below may also have other benefits, such as reducing the consumption of sample and solvent.

a) **Direct Aqueous Injection.** Although a potentially powerful analytical technique, the use of direct aqueous injection with gas chromatography may present technical difficulties in chromatographic separation and may reduce the lifetime of the GC column and the detector. However, some modern GC capillary columns are designed to survive the rigors of direct aqueous injection, provided appropriate QC is applied to instrument operations and required maintenance is performed. For the high concentrations of contaminants that may be present

during an emergency incident, the use of direct injection of aqueous samples with GC/MS library matching may prove valuable, particularly for initial and rapid screening of analytes for which laboratories do not possess the equipment utilized in a standardized method. For all but a few analytes, analytical confirmation procedures may be necessary, and laboratories should plan carefully, in terms of developing skills to applying this technique, verifying their GC columns are suitable, implementing QC requirements, and preparing for additional maintenance requirements of both column and detector.

b) **Micro Liquid-Liquid Extraction (micro-LLE).** Liquid micro extraction involves the use of small volumes of solvent (~ 2 mL) to extract analytes from a small volume (~ 40 mL) of water (for an example, see EPA Method 551.1). This approach is usually much quicker than the typical LLE because of the ease of the microextraction and because no concentration/solvent exchange is required. If the analyte is known, then a calibration standard should be analyzed along with other requisite quality control samples to quantify the analyte. If the analyte is unknown, then a screening approach should be taken. The extraction may be immediately followed by GC/MS analysis, which can provide qualitative identification from the mass fragmentation library search. Analytical confirmation procedures may be necessary, and laboratories should plan carefully in terms of QC requirements and additional maintenance requirements of both column and detector. For the high, perhaps acutely toxic, concentrations of contaminants that may be present during an emergency incident, the use of liquid-liquid microextraction of aqueous samples with a suitable solvent, such as methylene chloride (dichloromethane) **may prove particularly valuable**, particularly for initial and rapid screening of analytes for which laboratories do not possess the equipment utilized in a standardized method. Micro-LLE may not provide adequate detection limits for lower concentrations, which may occur if the water sample represents the tail of a transient contaminant slug.

c) **Continuous Liquid-Liquid Extraction (Cont LLE).** This technique, as described in EPA Method 3520C, is applicable to the isolation and concentration of water-insoluble and slightly soluble organics. Its use can result in excellent detection limits, like solid-phase extraction described below, although detection limits for specific analytes may be different.

d) **Solid-Phase Extraction (SPE).** Solid-phase extraction (sometimes referred to as liquid-solid extraction) is described in Section 6.4.2 for EPA Method 525.2 as one of the techniques for basic screening analysis. Like micro liquid-liquid extraction, SPE extracts many contaminants, but can achieve larger concentration factors compared with the former technique, which may be necessary for some analytical goals (Section 1.3). However, many variants of the solid-phase extraction technique are possible. For instance, instead of using a C18 adsorbent, there are many other adsorbents available. The adsorbents have markedly different properties and may be used to extract contaminants that are not amenable to C18 adsorbents. Different elution solvents can also be used as an experimental variable. As a safety note, SPE should produce few aerosols.

e) **Solid-Phase Microextraction (SPME).** A relatively recent variation of solid-phase adsorption is solid-phase micro extraction (SPME). Like SPE, SPME should produce few aerosols. SPME involves the use of a fiber coated with sorbent material, and the sorbent coated fiber is exposed to either the aqueous sample or the headspace from the sample. The analytes then adsorb to the coating on the fiber. After exposure to the sample, the fiber can be introduced

into the detection system, although the technical details depend on the detector (i.e., GC or HPLC). For instance, after exposure to the sample, the SPME fiber is inserted into the injector of a GC, and contaminants are released to the column by thermal desorption. Fibers are available with several types of coating to enable extraction of analytes of different properties, such as volatiles or semivolatiles. Accordingly, SPME could be used for a quick screen. As with micro-LLE, another quick screen, the detection limits may only be useful in the case of elevated, perhaps acutely toxic, contaminant concentrations. Lower concentrations like those found in the tail of a transient contaminant slug, might not be detected using SPME.

f) **Headspace Collection.** The headspace above an aqueous sample may be injected in a GC. Commercial equipment, interfaced with the GC, is designed to facilitate this analysis, although manual injections may be made.

g) **Flow Injection.** In the flow injection analysis experiment, an aqueous sample or sample extract is injected directly into an LC/MS in such a manner that it bypasses the LC column. Thus, the analytes are not chromatographically separated, but the technique can prove useful if high concentrations of a single analyte are present, or if sample preparation is employed that is selective of particular analytes.

Detection Techniques

a) **Multidetector GC in Screening Mode.** In Table 4-3, a multidetector GC is utilized for specific analytes as an alternative to a mass spectrometer. However, the intent of using multidetector GC in the analysis of unknowns is primarily as a screening tool, not necessarily to quantify or identify, but rather to determine if the sample contains a component not normally found in the background. Multidetector (sometimes called multispectral) GC refers to the use of GC with a variety of detectors (there are over a dozen on the market) and then comparing the data from all the detectors. Examples of detectors include atomic emission, electron capture, infrared, flame ionization, nitrogen-phosphorus specific, thermal conductivity, etc.

Various GC detectors respond to contaminants in different ways, and the evaluation of all the data from the various detectors increases the selectivity of the analysis. For example, detectors like flame ionization detectors tend to respond to most contaminants (but not with high sensitivity), while electron capture detectors respond with great sensitivity (but mostly to halogenated compounds and are less sensitive to certain other compounds). The detectors may be used in series with one GC, or in parallel through the use of multiple GCs. In the latter case, the peaks are correlated through the use of relative retention times, i.e., the retention time of the peak of interest compared to a standard. Multidetector GC should be applied carefully because of differing response of different detectors to coeluting contaminants, and confirmatory/supplemental analysis may be necessary. For the expanded screen, because methods are used other than the standardized EPA methods for drinking water compliance monitoring, it may be possible to utilize other detectors than specified in the standardized methods.

b) **Gas Chromatography with Electron Impact Ionization Mass Spectrometry**. The subsequent analysis of contaminants extracted from water may be conducted by the use of gas chromatography/mass spectrometry. When the mass spectrometry is performed using electron

impact ionization, eluting peaks may show distinctive fragmentation patterns, which may be used in identification, particularly through the use of a variety of computerized tools for library matching to ionization patterns of known compounds. Thus, the use of electron ionization in full scan mode (i.e., *m/z* 35 to the upper scan limit of the particular instrument) may be particularly useful when performing the analysis for unknowns using the GC/MS for analyte separation and detection. Note that for the analysis of small molecules, it may be necessary to start the scan below *m/z* 35.

It is desirable to review peaks that do not match the retention time of analytes listed in the method. Water samples may contain hundreds or thousands of compounds, so each laboratory must decide a threshold for examining unidentified peaks. For instance, as a starting point, the laboratory may attempt to identify an unknown peak if it is present at >10% (height threshold) of the internal standard using the automated programs that are available with many instrument software packages. The threshold may need to be reduced (e.g., to 1%) or increased (e.g., to 20%) depending on the sampling location, as water samples vary in the number and intensity of their normal background peaks.

Usually, the program performs a spectral search using a user-defined library (such as NIST, EPA, Wiley, etc), and will report the compound with the best spectral match as the tentatively identified compound with an estimated concentration (based on height, assuming a response factor of 1.0). Some of the guidelines in evaluating the spectra are:

- The major ions in the reference spectrum (ions greater than 10% of the most abundant ion) should be present in the sample spectrum.
- The relative intensities of the major ions should agree within +/- 20%.
- The base mass ion present in the reference spectrum should be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible coelution or background contamination.

Identification of unknown compounds relies on more than the efficiency of the library search program. The expertise of the analyst in evaluating the mass spectra and library matches is critical for assigning a tentative identification to the unknown. Electron impact mass spectrometers may vary slightly by manufacturer, vintage, and mass analyzer design. An analyst's familiarity with the nuances of a particular instrument may greatly enhance a laboratory's ability to confidently identify an unknown. In addition, there are a number of options within library search software, such as fitting algorithm, threshold parameters, result constraints, etc., and a particular analyst may be more proficient with one of these options for performing library-enhanced identification. For example, one approach may be that if the mass spectral library "reverse fit" is greater than 800 (of a possible 1,000), the peak is reported as identified in the report. If the fit is 600-800, the analyst should review the library search to determine if the identification was skewed by a coelution or high background. If the analyst is not able to improve upon the initial identification (fit between 600-800), the unknown should be listed by the class of compound assigned to that peak (e.g., "alkylated aromatic", "halogenated aliphatic", etc.) and an approximate molecular weight. If the report finds an unknown with a fit below 600, and the analyst cannot improve on the identification, the peak should simply be listed

as "unknown." The library search report should be scrutinized by an experienced GC/MS analyst to determine how the "unknowns" should be reported.

The above procedures are based on the library match and represent only a tentative identification. To increase confidence in the identification, a reference standard can be purchased, when available, to help confirm tentatively identified compounds. Primary dilution standards may be prepared and analyzed using the same procedure as for samples. Comparison of the retention time and mass spectrum of the known reference standard with the data from the unknown may verify or negate the tentative identification.

c) **High Performance Liquid Chromatography-UV Detector.** Analogous to multidetector GC, HPLC with UV detection can be used to determine if organic compounds not amenable to gas chromatographic procedures (e.g., nonvolatile or thermally unstable compounds) are present in amounts greater than background. Calibration and quality control samples should be included to provide an accurate analysis. Analytical confirmation may be necessary using established techniques, such as GC/MS. Due to technical issues with different HPLC methods, some laboratories currently dedicate HPLC instruments to standardized methods currently being run in the laboratory. Accordingly, it may be desirable, albeit not always practical, to dedicate an HPLC instrument to screening activities.

Analysis for specific pesticides and other chemicals are possible, and various HPLC methods for specific chemicals appear in the sources of methods described in Section 6.2. Screening procedures using HPLC may be more successful if targets are selected. For instance, a HPLC analysis for pharmaceutical compounds of concern in water might be developed to supplement existing methods. This method would probably involve some type of extraction (micro-LEE, SPE, SPME, etc.) and analysis by HPLC with UV detection. Contaminants in the extracts can be separated with HPLC and detected through the use of a UV photodiode array detector (PDA), which can record a UV spectrum that can be used for qualitative identification, although not always definitely. If peaks cannot be identified from the UV spectrum, LC/MS, described below, may be attempted under the exact same conditions (e.g., chromatography column and elution solvent program), provided such conditions are consistent with LC/MS operation.

d) **High Performance Liquid Chromatography-Mass Spectrometry (LC/MS).** Many polar hydrophilic compounds cannot be easily extracted from an aqueous sample. In addition, there are contaminants of large molecular weight (e.g., biotoxins) or thermally unstable compounds that are not amenable to GC analysis but can sometimes be analyzed by LC/MS. Direct aqueous injection HPLC allows analysis of a sample without extraction or concentration. SPME and SPE (and other extraction procedures) may be utilized for compounds that can be extracted. Identification of unknowns can be performed but there are no standardized (EPA, NIST, Wiley, etc.) mass spectral libraries, as in GC/MS. Analyst interpretation can help identify possible compound fragments and structure. There are several ionization techniques available. Two of the more popular ones that fall into the category of atmospheric pressure ionization (API) are atmospheric pressure chemical ionization (APCI), which allows the analysis of neutral analytes, and electrospray ionization (ESI), which allows the analysis of ionic analytes.

Analysis of samples by LC/MS is often not a straightforward or conclusive endeavor, due to complexities of the ionization process. For instance, depending on the composition of the sample, when ESI-MS is operated in the positive ion mode, it can produce $[M+H]^+$, $[M+Na]^+$, and other adduct ions, which sometimes can be useful to the analyst and sometimes confounding. For this and other reasons inherent to ESI-MS, quantification may not be always as straightforward as with other LC detectors. Qualitative analysis of unknowns by LC/MS may be hampered because the technique is not readily amenable to the development of libraries, such as those available with electron impact ionization GC/MS. For qualitative analysis, LC/MS may be considered best suited to providing an estimate of the molecular weight of the compound.

In summary, more than a decade after its commercialization, LC/MS is not standardized for drinking water analysis, although it has proved extremely useful for analysis of target analytes in other industries. Nonetheless, LC/MS can be an added tool in an expanded screen for unknown chemicals in specific cases, and may be useful for certain classes of pesticides, such as carbamates. For the analysis of specific target compounds, a skilled analyst may be able to establish methods to analyze for pesticides and pharmaceuticals in a particular water matrix, thereby eliminating the need for a combination of HPLC detectors and derivatization schemes. However, these methods may not be as robust as standardized methods in terms of the analysis of waters from various sources. In addition, there may be many opportunities for misinterpretation and misapplication of LC/MS data, so additional analytical confirmation steps may be necessary to ensure confidence in and legal defensibility of the analytical results.

e) **Tandem Mass Spectrometry (MS/MS).** Both GC and HPLC may be utilized in conjunction with tandem mass spectrometry, also known as MS/MS. Different MS/MS instruments operate under different principles to achieve similar results, but in essence can be considered to be like two mass spectrometers connected by a collision cell. The first mass spectrometer separates ionized molecules, which are broken apart in the collision cell, and the resulting fragments are separated in the second mass spectrometer. This produces a great deal of information that can be used to identify the original molecules, but even when used with electron impact ionization, this technique does not necessarily produce searchable libraries. Like other advanced mass spectrometric techniques, MS/MS is not as widely available as MS and requires a high degree of skill. However, it can produce unique and powerful results in the right hands.

f) **High Resolution Mass Spectrometry (HR/MS).** GC or HPLC, combined with a high-resolution mass spectrometer, may provide exact mass data of an eluting compound, allowing for calculation of elemental composition of both molecular and fragmentation ions. This information is useful in the identification of unknown organic compounds, especially when the result of mass spectral library research is not conclusive or when the standard of a tentatively identified compound is not available. Careful quality control procedures are required, and the technique is not always definite, especially for unknown compounds, because many compounds may produce fragments with the same exact masses. Due to high capital cost and complexity of use, HR/MS is not widely available.

g) **Immunoassays.** There are a large number of immunoassay tests kits for organic chemicals, such as pesticides and biotoxins. These may be useful for screening a sample for specific unknowns either in the field or in the laboratory. These kits may be used for speed or if

instrumental methods are not available in a laboratory. However, use of these kits requires that the goals of the analysis be planned because some kits are slower than the instruments, especially if analytical confirmation time is considered. Also, appropriate training is necessary in the use of these tests. Not all are the same, or easy to use. Laboratories should be aware of the kits' reliability and levels of detection before using.

A large collection of test kits for chemicals, such as carbamate and quaternary ammonium pesticides, and many other contaminants is summarized at http://www.aoac.org/testkits/TKDATA2.HTM. This is by no means a complete list, and there are a number of vendors with products not in this listing. It is important to note that most of these test kits are not recognized by any standard setting organization. Not all of these products have been studied in detail as to their efficacy for drinking water, which may contain interfering and/or cross-reacting substances. Efforts are underway to confirm the efficacy of some of these kits for particular purposes, and as results become available, they may be reported in the Module 3, Section 3.2. In the meantime, it may be important to keep in mind the trade-offs these kits offer in terms of sample throughput and false negatives/positive results. In general, a positive result from one of these test kits should be considered tentative and confirmed through a more rigorous laboratory analysis.

Immunoassays have been developed for the analysis of urine for chemicals that may be classed as illicit pharmaceuticals (e.g., narcotics and psychedelics). While it seems unlikely that these substances would be used as water contaminants, there is some historical precedence for concern. Immunoassays represent a very sensitive approach to screening of these compounds, and they are available from a variety of sources. Because many of these tests were designed for urine analysis, the performance of these tests for detecting the parent compound in water should be verified, due to the potential for cross reactivity with substances in water, which may result in a false positive detection. Because immunoassays may be interfered with by chlorine-based disinfectants, the residual should be quenched before use. Established procedures also exist for the analytical confirmation of many of these substances from urine using techniques such as GC/MS.

6.5.2 Expanded Screening of Inorganic Chemicals

Like the determination of organic chemicals, there are often a number of similar preparation steps that are used in the analysis of inorganic chemicals. These are numerous and vary with the methodology being employed. As a starting place to select a sample preparation approach, it may be useful to refer to relevant standardized methods. For instance, if the goal is to look for trace metals not listed in a particular method, it may be useful to refer to a method in which the sample is prepared for metal analysis. This is not necessarily an exact process, and some metals have certain characteristics that may cause them to not be amenable to a preparation technique applicable to another. For instance, a digestion method for nickel may not be applicable for mercury analysis. Following preparation, the samples may be analyzed by a number of techniques:

a) **ICP-AES or ICP-MS in Semiquantitative Mode.** Analogous to multi-detector GC and HPLC with UV detection, the ICP-AES and ICP-MS methods (EPA Methods 200.7 and

200.8, respectively) can also be expanded to provide a broad screen approach to identifying unknown trace metals. Under the semiquantitative mode (SQM, referred to by various names depending on instrument manufacturer), the ICP-MS instrument, operated in scanning mode, may be capable of providing semiquantitative results for more than 60 elements including major atomic cations, metals, semi-metals, rare earth elements and selected radionuclides (uranium and thorium) without actually including all of the elements being analyzed in the calibration standards. If an element is suspected, then standards may be obtained to perform quantitative analysis. (Note: radioactive materials should be handled by a specialized laboratory.) Some ICP-AES instruments can provide semiquantitative results for many, albeit fewer, elements than ICP-MS instruments, most of which are capable of SQM through the use of the correct software. The following paragraph discusses ICP-MS operated in scanning mode, and SQM for appropriate ICP-AES instruments functions analogously.

The original calculation algorithm of SQM may be applicable to all naturally occurring elements. Additional information may be obtained for elements that are not considered in the default algorithm, such as man-made radioisotopes or stable fission products with long half-lives, especially for isotopes in mass range between 210 and 238. Under the SQM mode, the concentrations of the naturally occurring elements are calculated based upon instrument response factors (RF) for each element. No internal standards are necessarily added when using the SQM method. Following the external calibration procedure, a blank and a single calibration standard of 20-30 elements are typically used to update the RF before each analytical run. Increasing the number of elements in the standard generally may improve the accuracy of the analysis. For elements not included in the calibration standard, the RFs are updated indirectly by software interpolation from the calibrated elements. SQM identifies and assigns signal intensity based upon the natural abundance distributions for each isotope, corrects the molecular interferences by subtracting the signal of the assigned polyatomic species from the total signal, further corrects for polyatomic and isobaric interferences given in the elemental equation, and calculates the final concentration.

b) **Ion Chromatography (IC).** Ion chromatography forms the basis of several EPA methods to determine ions of regulatory interest, such as EPA Method 300.1 for several common drinking water ions and disinfection byproducts. By the correct choice of operating conditions and ion chromatography columns, determination of many different types of ions have appeared in the literature, including those for some potential, albeit not high priority, drinking water contaminants of concern from a drinking water security perspective.

c) **Wet Chemistry.** Wet chemistry forms the basis of many types of chemical test kits. The chemistry and detectors for test kits approved for compliance monitoring are traceable to EPA methods. Wet chemistry techniques, through the use of so-called “autoanalyzers,” form the basis of many types of chemical analysis, for environmental and clinical applications. Manufacturers of these devices often provide full detailed methodology for defensible application of wet chemistry to a variety of analytes. Titrimetric methods are also available and can be used to analyze background water quality parameters such as alkalinity.

d) **Ion Selective Electrodes.** Ion selective electrodes (ISE, also known as electrochemical probes) can be utilized to analyze for some background water quality parameters. A simple example of an ISE is the familiar pH probe for the hydrogen ion. Other ISEs for a variety of ions (such as ammonia, calcium, chloride, fluoride, nitrate, potassium, silver, sodium, and sulfide) also may be available from a variety of manufacturers and may be considered. Some parameters that can be monitored by ISE may be useful in characterizing the extent of contamination or verifying credibility of a contamination threat (see the discussion on field testing in Module 3).

6.5.3 Expanded Screening of Cyanides

Expanded screening of cyanides typically involves the use of sample preparation techniques and wet chemical detection chemistries that are not used in standard EPA methods. For instance, the distillation step may be omitted, as it is for cyanide methods based on the Conway diffusion technique. Note that distillation is required for determination of total cyanide concentration, which, as discussed in Section 6.4.7, may be the most conservative approach with respect to public health implications. However, free cyanide concentration measured without distillation, may still be useful, particularly in detecting high, acutely toxic concentrations

Distillation also is not used in the rapid field tests for cyanide (Section 4.1), but may be applicable for expanded cyanide screening. As discussed in Section 3, some laboratories may consider using these rapid field tests as safety screening tests upon receipt of the sample by the laboratory. Note that several rapid field tests for cyanide have been evaluated as part of EPA's Environmental Technology Verification program, including some ion selective electrodes. The reports, available at http://www.epa.gov/etv/verifications/vcenter1-23.html indicate that some of these rapid field test kits, although acceptable for field use, may perform better when used under controlled laboratory conditions than in the field, especially in cold weather.

6.5.4 Expanded Screening of Biotoxins

Some biotoxins have been monitored routinely for quite a while, particularly in conjunction with naturally occurring outbreaks of biotoxins in marine environments. There are hundreds of biotoxins from dozens of different plant and animal species. The broad screening for microbiological contaminants (Section 8) may capture some of the higher molecular weight biotoxins, and analysis of some biotoxins may be supported by LRN laboratories, as indicated in Table 4-1. In addition, the LRN currently may utilize immunoassays for biotoxin analysis of botulism, ricin, and other biotoxins where applicable. The results of the LRN analysis should be further communicated to any other laboratories to which chemical samples are sent.

Immunoassays. Many/all of the biotoxins listed in Table 1-1 have commercially available immunoassay kits. A large collection of test kits is summarized at http://www.aoac.org/testkits/TKDATA2.HTM. This is by no means a complete list, and there are a number of vendors with products not in this listing. It is important to note that most of these test kits are not recognized by any standard setting organization, and the applicability of these products to disinfected drinking water, which may contain interfering and/or cross-reacting substances, is not well studied. Efforts are underway to confirm the efficacy of some of these

kits for particular purposes, and as results become available, they may be reported in the Appendix to Module 3 that lists field test equipment. In the meantime, it may be important to keep in mind the trade-offs these kits offer in terms of sample throughput and false negative/false positive results. In general, a positive result from one of these test kits should be considered tentative and confirmed through a more rigorous laboratory analysis.

A key part of laboratory analytical screening for a biotoxin is the ability to confirm its tentative identification (e.g., via an immunoassay test kit). Confirmatory analyses are discussed in more detail below, and usually involve GC/MS, LC, or LC/MS. The IOC Manual on Harmful Marine Microalgae, available at http://unesdoc.unesco.org/images/0012/001220/122021eo.pdf, contains many examples of these types of analyses, chiefly intended for analysis of algal biotoxins. One type of assay that has been widely used for the determination of biotoxins in seafoods over the past 60 years is the mouse bioassay. The applicability of this technique to water samples is not well investigated, and most laboratories do not have facilities for the care of laboratory animals. In addition, immunoassay techniques are less sensitive than instrumental analysis techniques.

The biotoxins may be considered as organic chemicals, and the same types of sample preparation and instrumental analysis techniques may be applicable, depending on the molecular weight of the biotoxin. Low molecular weight toxins may be treated much like any organic chemical described in Section 6.5, and may be analyzed by the same type of analytical techniques (e.g., GC/MS) as described therein. Because biotoxins tend to be very water soluble, liquid chromatography techniques have been used to determine biotoxins in water. When LC/MS is used, the same precautions may be necessary as those for other organic chemicals (see Section 6.5.1). The analysis of biotoxins is one area where LC/MS has proved particularly valuable, especially if the molecular weight of the biotoxin precludes its analysis by GC/MS. Again, the skill of the analyst is critical in obtaining meaningful results for LC/MS analysis of biotoxins.

6.5.5 Expanded Screening of Radionuclides

Radiological analysis, as noted above, should be performed only by licensed, specialty laboratories, and the need for such analysis should be indicated by the field screening equipment for alpha, beta, and gamma emitters. As discussed in Module 3, the site characterization will determine the appropriate laboratory to receive radioactive samples (e.g., high levels of radiation would indicate a radiation hazard, and only the appropriate radiation laboratory would receive the sample). If the laboratory should wish to screen samples before accepting them or analyzing them, then inspection of samples for alpha, beta, and gamma radioactivity using probes for these emitters may be prudent (e.g., the devices used by the first responder/sample collector as described in section 3.1.4). Again, a positive test from the screening devices should be sent to specialty laboratories for confirmatory analysis.

The basic screen discussed in Section 6.4.8 is rather comprehensive because it requires identification of the specific radionuclide if indicated by the screens for gross alpha, beta, and gamma radiation. Therefore, the expanded screen is designed to capture radionuclides that do not fall into the energy range of the gross radionuclide screen for gross alpha and beta. Fortunately, these radionuclides have specific EPA 900-Series methods designed for their

analysis, and radionuclide laboratories may be familiar with these few radionuclides and have other reliable methods at their disposal for their analysis.

Two other techniques that may be particularly useful for radionuclide analysis are gamma spectroscopy, which can directly identify the gamma emitting radionuclide and inductively coupled plasma mass spectrometry (ICP-MS). Principal considerations in the use of both of these techniques include detection limits and availability of instrumentation. Often, these considerations are based on the particular radionuclide involved. To better understand and deal with the needs and roles of the wide variety of analytical radiochemistry techniques at the disposal of radionuclide laboratories, the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual has been developed by the Environmental Protection Agency, the Department of Energy, the Nuclear Regulatory Commission, the Department of Defense, the National Institute of Standards and Technology, along with some states (http://www.epa.gov/radiation/marlap/). This effort is but one component in the EPA's Radiological Emergency Response Plan (http://www.epa.gov/radiation/rert/docs/rerp-1-00.pdf) in support of EPA's responsibilities for protecting the environment and in support of the Federal Radiological Emergency Response Plan (http://www.nrt.org/production/nrt/home.nsf/0/5c23c5d58074d6e48525660c005b56b5?OpenDocument).

6.5.6 Expanded Screening of Chemical Weapons

As discussed in Section 2.1.4, the term *chemical weapons* refers to the substances, such as those shown in Table 1.1, that appear on Schedule 1 of the Chemical Weapons Convention (CWC, http://www.cwc.gov/Regulations/cfr-15/part-712-s1_html). There are other substances, such as chemical weapon precursors, that are monitored by the CWC under Schedules 2 or 3, which also may be present in water at very low concentrations (typically less than 10 µg/L) due to industrial pollution or the formation of disinfection byproducts. Table 4-18 in the Appendix (Section 10) lists the Scheduled chemicals. Chemicals on Schedules 2 or 3 have fewer restrictions compared with Schedule 1, since many have legitimate industrial applications. Thus, environmental laboratories could potentially analyze for many Schedule 2 or 3 chemicals. This section focuses on the analysis of Schedule 1 chemicals, which are most restricted.

The Schedule 1 agents used as chemical weapons are extremely hazardous to handle and most environmental chemistry laboratories do not have the facilities or the procedures in place to handle these agents. In addition, most of the agents are not available commercially to prepare analytical standards for quantification. The chemical weapons agents will need to be analyzed by special chemical weapons laboratories for confirmatory analysis. However, in the unlikely case that an environmental chemistry laboratory receives a sample containing a chemical weapon, screening techniques can be used by environmental chemistry laboratories to identify the presence of the agents in water.

The best analytical approach may be to utilize the preparatory procedures (direct injection, micro-LLE, SPE, and/or SPME) as discussed above, followed by GC/MS for identification. This may only be able to determine the presence, not concentration, of the agent because an analytical standard would not be available. However, the standard electron impact mass spectral libraries

frequently contain mass spectra of these compounds and can be used for tentative identification. As an aid to increasing confidence in chemical warfare agents' GC/MS library matches, the National Institute of Standards and Technology has developed the Automated Mass Spectral Deconvolution and Identification System (AMDIS), http://chemdata.nist.gov/mass-spc/amdis/.

In the unlikely case CW agents are present, the expanded screen for organic chemicals may be procedurally designed to reduce risk, namely through reduction of aerosols. As with any organic chemical, an additional way to reduce risk would be through sample dilution. The laboratory may first start with the most dilute sample (1/1,000) and if nothing is detected may proceed to analyze the next dilution (1/100), followed by the 1/10 dilution, and lastly the undiluted sample. If the laboratory proceeds through the undiluted sample and nothing is detected, the sample may be deemed non-detect for the chemical weapons that would be captured by the screen. If the chemical weapons agents are identified in the screen, proper notifications should be made to law enforcement to gain access to laboratory resources that can confirm the presence of the chemical weapons agent.

7 Examples of the Analytical Approach to Site-Specific Situations for Chemical Contaminants

Section 6 describes an analytical approach based on chemical contaminants considered important from a national perspective. As noted above, local authorities may wish to develop their own analytical approach based on their perceived needs and concerns. Here are some brief examples of analytical approaches based on the concept of basic and expanded screening. The first five (Section 7.1) are derived from the needs of specific, hypothetical utilities, and the final three (Section 7.2) are geared toward laboratories that serve a wider base of clients.

The overriding principle in these examples is the flexibility that laboratories have in developing and updating an analytical plan for the analysis of unknowns in water. Utility laboratories may have the greatest level of flexibility with respect to the comprehensiveness of their screen **if** they have made arrangements with other labs to perform more comprehensive screening as necessary. For example, utility laboratories may choose to perform some level of basic screening that may be applied in the case of a **'possible'** threat; however, analysis may need to be performed at another laboratory in response to a threat deemed **'credible'**. On the other hand, laboratories that serve a wider customer base should have a more comprehensive and robust screening procedure to cover the range of potential scenarios that might be encountered in working with various utilities.

7.1 Examples for Utility Laboratories

These five examples are targeted at **utility** laboratories that chose to develop an analytical approach to support analysis of their own emergency water samples, and make arrangements to engage other laboratories with broader capabilities when necessary. This is to say, it is part of upfront planning for a utility to decide when they will handle samples in-house and when they will send them to external laboratories. In many of these examples, the utility laboratories often take a "springboard" approach to screening, using the results of the basic screen to make decisions in the expanded screen.

Example #1: Based on the results of a vulnerability assessment, a local water utility has concluded that their consumers are at only a very small risk from water contamination incidents, and so do not want to invest much of their limited resources in overly detailed analytical approach. They possess a purge-and-trap-GC instrument with conventional photoionization and electrolytic conductivity detectors in series, and are certified to perform analysis of Method 502.2 analytes. They possess a GC/MS for another purpose, so they choose to expand their laboratories capabilities by making a small purchase of a solid-phase extraction manifold and supplies suitable for Method 525.2 analytes. They allow their laboratory staff the time to become proficient with Method 525.2 to ultimately obtain certification by their state. In the meantime, they plan on using the technique in the expanded screen. They decide to exclude carbamate pesticides and quaternary ammonium compounds from their analytical approach because they are not available anywhere nearby, and the utility does not believe that they will be important because there are *opportunity contaminants* available locally. One of these opportunity contaminants is glyphosate, which, although not very toxic to humans, is widely used in the area. They search NEMI, or another source such as those listed in Table 4-2, and find

a suitable method. They do not possess any capability for trace metal analysis, so they contract this out to a third party who performs Method 200.7. In looking at the analyte list for Method 200.7, the laboratory sees that mercury can be analyzed by Method 200.7 and seeks data from the contracted third party that their instrument provides sufficient detection limits for arsenic and mercury. The utility laboratory realizes Method 200.7 most likely will determine many organomercury compounds (as total mercury), so they decide that the benefit of enhancing their mercury screening capabilities through the addition of Method 245.2 to their basic screen is not worth the expense. In their locality, the first responders to contamination incidents possess, and are trained in, the use of portable cyanide detection systems and radiation detectors. They buy a low-cost gamma detector to screen samples in the laboratory as a safety precaution. Thus, instead of Table 4-3, their basic analysis may be summarized in Table 4-5. Clearly, this is not as rigorous as Table 4-3, but does meet many of the same needs.

During an incident, if the threat evaluation and site characterization indicated that greater analytical capability is required for expanded screening or confirmatory analysis, they plan to rely on state resources, although there is a four-hour delay in getting the samples to the state laboratories. If the water utility emergency response manager (or the designated incident commander) must have results faster, they plan to perform direct aqueous injection into their GC/MS with the hope of getting a successful GC/MS library match. They also consider performing a micro-liquid liquid extraction using methylene chloride for the same purpose. However, due to the resulting additional instrument maintenance requirements, which may make the instrument unavailable for its intended purpose, they do not want to do this routinely.

Table 4-5. Basic Screen for Chemical Analysis for Example #1

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap PID/ELCD	502.2
Semivolatiles (organic)	Solid-phase extraction GC/MS	525.2
Trace metals (inorganic)	Contracted out	200.7
Cyanides	By first responders	N/A
Radionuclides	By first responders	N/A
Local contaminant (Glyphosate)	HPLC-UV	547

Example #2: A utility laboratory has a great number of legally defensible protocols (some of which are EPA methods) already in place, except for radionuclides, which are handled by a separate department. They examine the analytes in the methods in Table 4-3, and determine to the best of their ability and interest that their protocols already cover all the contaminants about which they are concerned. Thus, their version of an analytical approach for chemicals may appear as shown in Table 4-6.

Table 4-6. Basic Screen for Chemical Analysis for Example #2

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	In-house protocol
Semivolatiles (organic)	Solid-phase extraction GC/MS	In-house protocol
Carbamate pesticides (organic)	Derivatization GC/MS	In-house protocol
Quaternary nitrogen compounds (organic)	HPLC – UV	In-house protocol
Trace metals (inorganic)	ICP-MS	In-house protocol
Total mercury (including organomercury compounds)	Cold vapor AA	In-house protocol
Cyanides	Wet chemistry	In-house protocol
Radionuclides	First responders	In-house protocol

In addition, the laboratory possesses a significant capability in terms of instrumentation and analytical expertise to perform the expanded screening analysis, such as interpreting electron impact mass spectra and performing immunoassays. Thus, Table 4-6 is consistent with their needs and may comprise their analytical approach.

Example #3: A water utility decides its water security concerns are reflected in the approach presented in Section 6. The utility has access to laboratories that are capable of performing the methods in Table 4-3, except radionuclide analysis, which is handled by emergency responders in accordance with state policy. However, they do not have access to expanded screening techniques, and choose not to include in-house expanded screening, since their local emergency operations policy does not allow time for detailed expanded screening. Thus, decisions would typically be based on the results from the basic analytical screen. However, the utility has made arrangements with a commercial laboratory to perform some expanded screening if deemed necessary based on the circumstances of the incident.

Table 4-7. Basic Screen for Chemical Analysis for Example #3

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	524.2
Semivolatiles (organic)	Solid-phase extraction GC/MS	525.2
Carbamate pesticides (organic)	HPLC – fluorescence detection	531.1
Quaternary nitrogen compounds (organic)	HPLC – UV	549.2
Trace metals (inorganic)	Graphite furnace AA	200.9
Total mercury (including organomercury compounds)	Cold vapor AA	245.1 with persulfate
Cyanides	Wet chemistry	335.3
Radionuclides	Emergency responders	

Example #4: A water utility only has capability for basic water quality parameters, such as pH, turbidity, and chlorine residual. The utility has always sent samples to the state laboratory for routine analysis and does not have resources to do differently, even in the case of an emergency. They do, however, make plans for how to most efficiently deliver the samples to the state laboratory, and recruit employees from other city and county offices to help implement the plan if the regular staff of two persons is not available. Note that the techniques used by the state

laboratory (shown in Table 4-8) are the same as in Table 4-3. However, from the utility's perspective, the state laboratory governs the selection of the techniques.

Table 4-8. Basic Screen for Chemical Analysis for Example #4

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	524.2
Semivolatiles (organic)	Solid-phase extraction GC/MS	2525A/8270D
Carbamate pesticides (organic)	HPLC – fluorescence detection	531.1
Quaternary nitrogen compounds (organic)	HPLC – UV	549.2
Trace metals (inorganic)	ICP-MS	200.8
Cyanides	Wet chemistry	335.3
Radionuclides	Gross alpha, gross beta, gross gamma radiation	technique referred by state lab

Example #5: A utility laboratory has a purge-and-trap GC/MS, a regular GC/MS, and an ICP-MS. Their basic screen is represented in Table 4-9.

Table 4-9. Basic Screen for Chemical Analysis for Example #5

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	524.2
Semivolatiles (organic)	Solid-phase extraction GC/MS	525.2
Trace metals (inorganic)	ICP-MS	200.8

While this leaves some gaps in their analytical coverage, they plan to address these deficiencies through an expanded screen. They acquired immunoassay test kits that have undergone some level of validation, such as ETV (http://www.epa.gov/etv). For these and other kits, the laboratory understands the limitations of these test kits (see Section 6.5.1 and 6.5.4) and has arranged analytical confirmation of the analytes with state laboratories should the need arise. The laboratory also has an agreement with a local university that has a mass spectrometry facility including an LC/MS. The utility laboratory takes steps to ensure that the university laboratory/staff will be available in the case of an emergency and all chain-of-custody rules and legal defensibility issues have been met. The utility also has made arrangements to contract out the confirmatory analysis, if necessary. Although the utility recognizes there are potential problems with this arrangement, it believes this plan meets its needs.

7.2 Examples for Laboratories with a Wide Client Base

The concept of basic screening takes on a different dimension for laboratories that serve a wide client base because utility laboratories are most likely faced with 'possible' incidents. Accordingly, they may feel reasonably confident in the comprehensiveness of the screening procedures, illustrated in examples #1-#5. On the other hand, laboratories that serve a wide client base have a larger opportunity to receive a sample from a 'credible' incident. There are two reasons for this. First, these laboratories serve more clients, so on a strictly mathematical basis, they have a greater chance. Second, utility laboratories in 'credible' situations may be

more likely to refer samples to another laboratory, which may have greater capability to apply a more focused analytical approach in response to a specific incident (as discussed in Section 5).

Accordingly, laboratories that choose to perform analysis of emergency water samples and serve a broader client base, such as Federal, State, and commercial labs, may need to adopt a more comprehensive approach such that they maintain flexibility to provide analytical support in a variety of situations. However, as the following three examples illustrate, this goal can be met in a variety of ways.

The first two examples represent extreme cases of laboratories preparing to respond to a 'possible' and/or 'credible' incident. The first example represents a laboratory that does not define a basic screen and will perform analyses as part of a comprehensive expanded screening program. The second example depicts a laboratory that attempts to be comprehensive by including a very large number of standard methods in their basic screen. The third example blends the first two examples and adopts a screening approach that aligns closely with the complete "Basic Screen" (Table 4-3) and has some capability for the "Expanded Screen" (Table 4-4), as well.

Example #6. Utilities in a county are all serviced by the same central laboratory. However, the needs of the utilities are somewhat different, so after a meeting between all utility and laboratory representatives, it is agreed that the plan is to perform no basic screens. The decision was based on response times for utilities, mandated by the locality, being too short for the basic screen. The laboratory will instead perform the expanded screen using exploratory techniques that have short response time, such as those discussed in Section 6.5 (Table 4-4). The laboratory has skilled analysts and modern equipment and is confident of its capability. The laboratory also is capable of performing confirmatory techniques for some contaminants, if necessary. The planners realize that this approach may not meet all desired QC goals for every contaminant, but are prepared to live with the consequences of basing decisions on this kind of data.

Table 4-10. Basic Screen for Chemical Analysis for Example #6

Chemical (general class)	Analytical Technique	EPA Method
None	--	--

Example #7. A state laboratory that supports a large number of utilities. The laboratory performs many EPA drinking water and SW-846 methods routinely, and it wants to include as many techniques as possible in the basic screen. It chooses to do this since the needs of water systems it serves vary greatly, and most are small and understaffed to the point that the utilities generally rely on the state for all analyses and analytical decisions. The laboratory also realizes that only a broad screen will be sufficient to cover the majority of potential emergency scenarios that its utility clients may face. Also, the laboratory wants to exercise "due diligence" up to the level of a 'credible' threat, as defined by the threat evaluation , and it realizes that more analytes are captured by these methods than are in the basic screen in Table 4-3, and that some of the methods are more sensitive for particular analytes. In all, the laboratory feels that the inclusion of all these methods would be valuable for their clients.

Note that the laboratory chooses preparation methods for the SW-846 methods to make them compatible with the drinking water methods, so that it does not have to prepare the sample twice in many cases. The laboratory feels that its basic screen best meets the needs of its clients. It does perform some expanded screening to try to identify unknown chromatographic peaks in its analysis and through combining all the analytical results from the various techniques.

Table 4-11. Basic Screen for Chemical Analysis for Example #7

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	8260B
Semivolatiles (organic)	Solid-phase extraction GC/MS	3535A/8270D
Nitrogen and phosphorus-containing pesticides (organic)	GC/NPD	507
Chlorinated pesticides, herbicides, and organohalides (organic)	GC/ECD	508.1
Chlorinated acids (organic)	GC/ECD	515.1
Phenols (organic)	solid-phase extraction GC/MS	528
Carbamate pesticides (organic)	HPLC – fluorescence detection	531.1
Glyphosate (organic)	HPLC-UV	547
Quaternary nitrogen compounds (organic)	HPLC – UV	549.2
Chlorination disinfection byproducts, chlorinated solvents, and halogenated pesticides/herbicides (organic)	GC/ECD	551.1
Water soluble alcohols/non-chlorinated organics (organic)	GC/FID with direct aqueous injection	8015B/5031
Organochlorine pesticides (organic)	GC/MS	8081A
Organophosphorus compounds (organic)	GC/MS	8141A
Chlorinated herbicides (organic)	GC/MS after methylation or pentafluorobenzylation	8151A
Trace metals (inorganic)	ICP-MS in scanning mode	200.8
Total mercury (including organomercury compounds)	Cold vapor AA	245.2 with persulfate
Cyanides	Wet chemistry	335.3
Biotoxins	Immunoassays with confirmatory techniques	
Radionuclides	Gross alpha, gross beta, gross gamma radiation	technique referred by lab

Example #8: A laboratory serves an area that has several drinking water treatment plants located downstream from an agricultural area, an industrial area, and/or a nuclear power plant. In addition, there are geological formations that contribute to high inorganic contaminant levels. Fortunately, the laboratory is very well equipped and staffed, with strong capabilities and experience in monitoring all the classes of contaminants in Table 4-3. In addition, the laboratory expands the analyte list (see Table 4-20) for these methods to include as many analytes as possible.

Table 4-12. Basic Screen for Chemical Analysis for Example #8

Chemical (general class)	Analytical Technique	EPA Method
Volatiles (organic)	Purge-and-trap GC/MS	524.2
Semivolatiles (organic)	Solid-phase extraction GC/MS	3535A/8270D
Carbamate pesticides (organic)	HPLC – fluorescence detection	531.1
Quaternary nitrogen compounds (organic)	HPLC – UV	549.2
Trace metals (inorganic)	ICP-MS	200.8
Total mercury (including organomercury compounds)	Cold vapor AA	245.2 with persulfate
Cyanides	Wet chemistry	335.3
Radionuclides	Gross alpha, gross beta, gross gamma	technique preferred by lab

Due to sources of potential contaminants other than intentional contamination, the laboratory also maintains careful records of ranges of contaminants it normally encounters, so that during an emergency incident, it does not confuse background levels of contaminants with intentionally introduced ones.

For expanded screening, the laboratory utilizes its existing instrumentation with the techniques discussed in Section 6.5. The laboratory is particularly interested in developing an HPLC screen for pharmaceuticals (which it was already interested in due to potential regulatory issues), and would like to explore micro-LLE and SPME for this purpose. Therefore, the laboratory acquires the required equipment and supplies, and encourages its staff to investigate these techniques.

8 Analytical Approach for Biological Contaminants

8.1 Overview of Contaminant Issues

8.1.1 Types of Biological Contaminants Covered by the Analytical Approach

Two broad classes of *pathogens* may be encountered in a contaminated water sample: 1) traditional waterborne pathogens such as enteric bacteria, viruses and protozoa; and 2) exotic and select agents that may be suitable for a water route of transmission. Table 4-13 lists some of these pathogens. This section is intended as a guide for selecting analytical approaches for samples suspected of containing known and unknown microbial contaminants. Specific methodologies will be addressed in a laboratory analysis guide for biological contaminants (under development).

Table 4-13. General Classes of Pathogens, Specific Organisms, and Select Agent Status

Pathogen general class	Organism	Select Agent*
Bacteria (non-spore forming)	*Brucella* spp.	Yes
	Burkholderia pseudomallerei	Yes
	Campylobacter spp.	
	E. coli 0157:H7	
	Francisella tularensis	Yes
	Salmonella spp.	
	Shigella spp.	
	Vibrio cholerae	
	Yersinia pestis	Yes
Bacteria (spore forming)	*Bacillus anthracis*	Yes
	Clostridium botulinum A	Yes
Bacteria (Rickettsia)	*Coxiella burnetti*	Yes
Protozoa	*Cryptosporidium parvum*	
	Entamoeba histolytica	
	Giardia intestinalis	
	Toxoplasma gondii	
Viruses	Enteroviruses	
	Hepatitis A	
	Hepatitis E	
	Noroviruses	
	Rotavirus	
	Variola	Yes
	VEE	Yes
	VHF	Yes

* See http://www.cdc.gov/od/sap/docs/salist.pdf

8.1.2 Selection of Appropriate Analytical Approach for Contaminant Analysis

The analytical approach for these biological contaminants can be divided into two distinct steps, sample collection and sample analysis. All information prior to and during the threat evaluation (Module 2) needs to be carefully considered to assess the microbial contaminant threat and to

apply a relevant sample collection and sample analysis procedure. Different sample collection and analysis approaches are described below.

The overall approach for sample collection and analysis for microbial contaminants is based on the target contaminant. When the target contaminant is known, then established and validated technologies for sample collection and methods for analysis are utilized. When the target contaminant is unknown or when the contaminant is known but established and validated procedures for collection are not available, then an ultrafiltration device is used for sample collection and exploratory methods of analysis are utilized.

8.1.3 Microbial Sample Collection Considerations

Figure 4-8 illustrates the overall approach for sample collection for microbial contaminants. This approach utilizes established and validated sample collection techniques when the target contaminant has been tentatively identified based on available information from the site characterization report. Examples of situations in which tentative identification might occur include: a specific contaminant named in a threat; physical evidence at the site pointing to a specific contaminant; and clinical evidence of the identity of the disease-causing contaminant. In the case where the contaminant is unknown, sample collection is performed through the use of an ultrafiltration sampler (see Section 8.3).

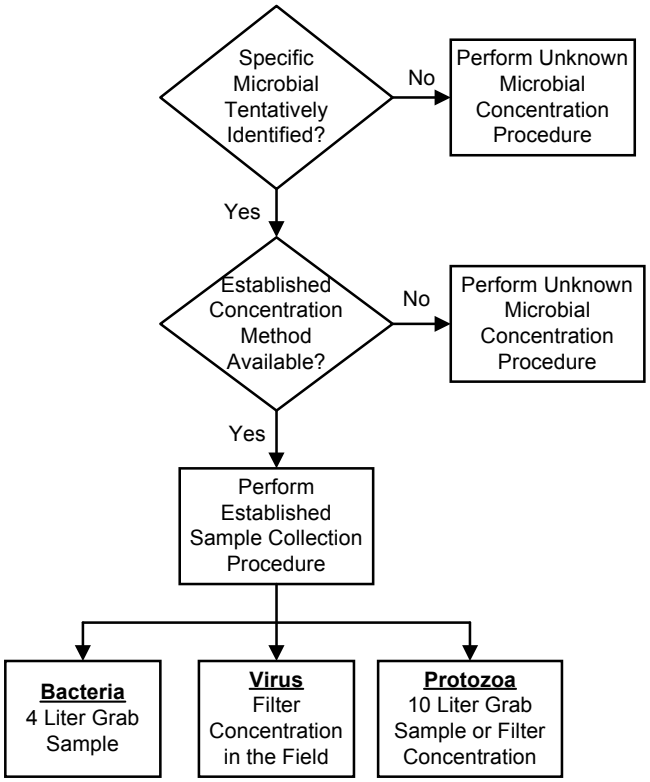


Figure 4-8. Analytical Approach for the Collection of Microbial Contaminants

The ultrafiltration approach may also be desirable for a number of reasons. First, the sample may contain a mixture of microbial contaminants. Second, due to the low infectious dose of most waterborne pathogens, a sample of 100 liters of finished water may need to be concentrated to obtain suitable detection limits. Third, sample concentration technology for viruses and protozoa require separate field equipment and procedures and are practical only if the microbial contaminant is suspected or identified as one amenable for concentration by each of these specific technologies. Thus, in a contamination threat or incident, it may be necessary to utilize a more general sample concentration procedure based on ultrafiltration that targets a wider range of microorganisms.

8.1.4 Microbial Processing and Analysis Considerations

Making a determination as to whether the microbial contaminant has been tentatively identified is important since it will determine the type of laboratory that can do the processing and analysis. Non-select agents or BSL levels 1 and 2 contaminants that are regarded as waterborne pathogens, including the enteric bacteria, viruses and protozoa, can be sent to an environmental laboratory. If the contaminant is unknown or is a select agent, the sample is to be shipped to a specialty laboratory (Figure 4-9).

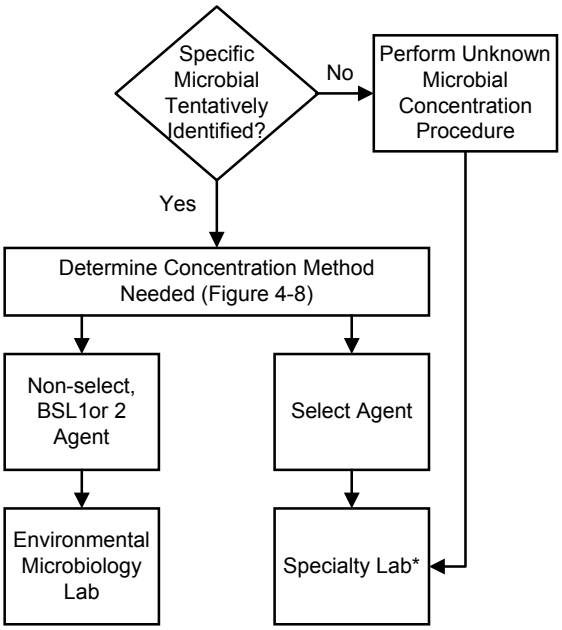


Figure 4-9. Approach for the Processing and Analysis of Microbial Contaminant Groups
*The specialty laboratory includes the Laboratory Response Network Laboratories among other specialty labs.

8.2 Established Techniques for Sample Collection of Known Waterborne Contaminants

If a microbial contaminant has been tentatively identified, the available and established techniques may be the more direct approach for sample collection and analysis. The advantage of these techniques is that a broader base of expertise and more analytical laboratories are available to water utilities than is available for select agents and for exploratory techniques.

Established and validated methods for sample collection and analysis of microbial contaminants in water are limited to a few microorganisms, mainly some enteric bacteria, viruses and protozoa, and a few other organisms with a known waterborne transmission route, listed in Table 4-14. If the contaminant is not known or the available site investigation and intelligence information is not considered sufficiently reliable for the use of an established method, the procedure for microbial unknowns (Section 8.4) is to be used.

Table 4-14. Known Waterborne Pathogens with Established Techniques for Sample Collection and Analysis

Pathogen (general class)	Organism	Analytical Technique	Method[1]
Bacteria	*Campylobacter spp.* E. coli 0157:H7 *Salmonella spp.* *Shigella spp.* *Vibrio cholerae*	Culture in selective media	SM 9260 G SM 9260 F SM 9260 B SM 9260 E SM 9260 H
Protozoa	*Cryptosporidium parvum* *Giardia intestinalis*	IMS/IFA[2]	EPA 1622/23 EPA 1623
Viruses	Enteroviruses Hepatitis A	Mammalian cell culture	EPA/600/4-84/013 EPA ICR manual

1. SM refers to Standard Methods for the Examination of Water and Wastewater (Clesceri *et. a.l.*, 1999). The EPA methods may be found at http://www.epa.gov/nerlcwww/
2. Immunomagnetic separation (IMS) and immunofluorescence assay (FA) microscopy.

8.2.1 Bacteria Collection with Established Techniques

The established sample collection procedures for bacteria are essentially *grab samples* that are later processed by membrane filtration of typically 100 milliliters to two liters. A four liter grab sample will allow for analysis for different bacteria by plating multiple membrane filters on separate selective or enrichment media. Special shipping regulations apply to samples known to contain pathogens (see Module 3, Section 6 for requirements for shipment of infectious materials, http://www.bt.cdc.gov/labissues/PackagingInfo.pdf). If select agents are not known or are not suspected to be in the water, then the sample is considered an environmental sample, and volumes of four liters or less can be collected and shipped using standard sampling containers.

8.2.2 Virus Collection with Established Techniques

The established sample collection procedures for viruses involve concentration on positively charged filters (ICR Microbial Laboratory Manual, EPA/600/R-95/178, April 1996, http://www.epa.gov/nerlcwww/). This method is reasonably effective for concentration of enteric viruses from large volumes of water. Samples in excess of 100 liters can be easily concentrated by this method. The ICR method has been used to concentrate 1,200 liters of finished water. The processed filters can be shipped to the laboratory, or viruses adsorbed to the filter can be eluted in the field and shipped as a one-liter concentrate to a laboratory for further processing by conventional reconcentration procedures.

8.2.3 Protozoa Collection with Established Techniques

The established procedure for protozoa sampling in water consists of obtaining a 10-liter grab sample or field concentration by filtration (Method 1623: Cryptosporidium and Giardia in Water by Filtration by IMS/FA, EPA-821-R-99-006, April 1999, http://www.epa.gov/nerlcwww/). The ten-liter grab sample or the filter is shipped to the laboratory for further processing.

8.3 Established Techniques for Analysis of Known Waterborne Contaminants

Established analytical techniques are based on culture assays in selective media for bacteria, selected cell lines for viruses and IFA with antibodies for protozoa identification (Table 4-14). Culture based techniques are not available for some contaminants and these techniques have long turn-around times for analysis. Thus, it may be necessary to utilize exploratory methods (Section 8.4.3) due to time restraints or the absence of an established culture method for a particular pathogen. Exploratory methods are primarily molecular-based, and involve PCR and probe hybridization as a *presumptive test*, followed by sequence analysis to confirm. If necessary, samples could be simultaneously analyzed by both rapid exploratory methods and established methods.

8.3.1 Bacteriological Analysis with Established Techniques

Sample collection for laboratory analysis of pathogenic bacteria in water samples consists of processing a grab sample by membrane filtration and transferring the membrane onto selective or enrichment media for presumptive identification (Figure 4-10). The enteric bacteria and other non-select pathogenic bacteria can be confirmed by conventional methods based on biochemical profiles, serological identification, or other culture based methods. The vast majority of enteric bacteria can be analyzed with BSL-2 containment level; thus an environmental laboratory with that containment level could proceed with confirmatory identification of non-select organisms.

If the presumptive tests indicate the possible presence of a select agent, the sample and the isolated culture must be referred to a specialty laboratory (Figure 4-10). Federal regulations prohibit the handling and maintenance of select agents unless the laboratory has registered with the CDC under the requirements of the Select Agent Rule (see Section 2.2).

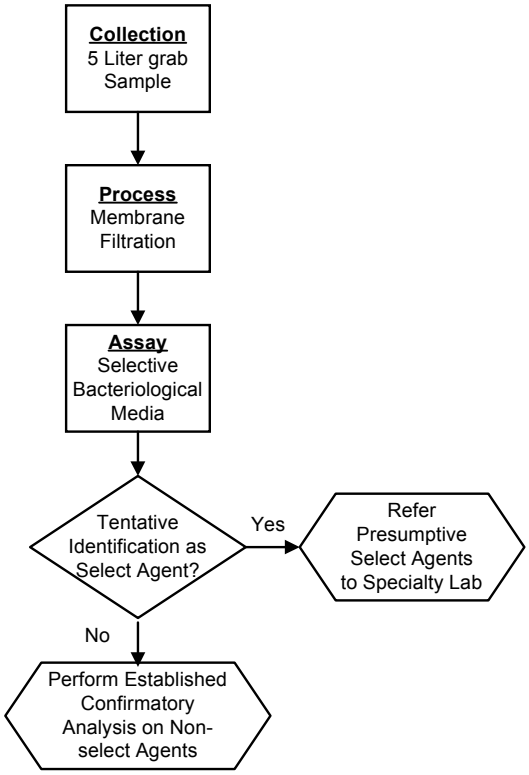


Figure 4-10. Bacteriological Screening with Established Techniques

8.3.2 Virological Analysis with Established Techniques

Established techniques for virological analysis consist of plating the sample concentrate on cell lines receptive to the target viruses. The target viruses anticipated in a water sample are the enteric viruses. There are cell lines receptive to a number of them (see Table 4-13). It may be necessary to inoculate a sample on multiple cell lines to cover the range of possible virus targets. A presumptive positive result of a cell culture test is the production of cytopathic effects on the cell monolayer as observed by light microscopy. Established virus confirmation and identification techniques consist of serological neutralization with specific antibodies against the various viruses or by means of pools of antisera with respective identification tables. If a presumptive identification suggests the presence of a select virus agent, the sample, culture and other processed sample materials must be referred to a specialty laboratory (Figure 4-11).

If an established technique is not available for a specific virus or if the virus is known not to grow in cell culture, exploratory PCR-based techniques may be the more appropriate approach for presumptive identification. Presumptive identification is based on PCR amplification and probing. Analytical confirmation is conducted by sequence analysis of the amplified material.

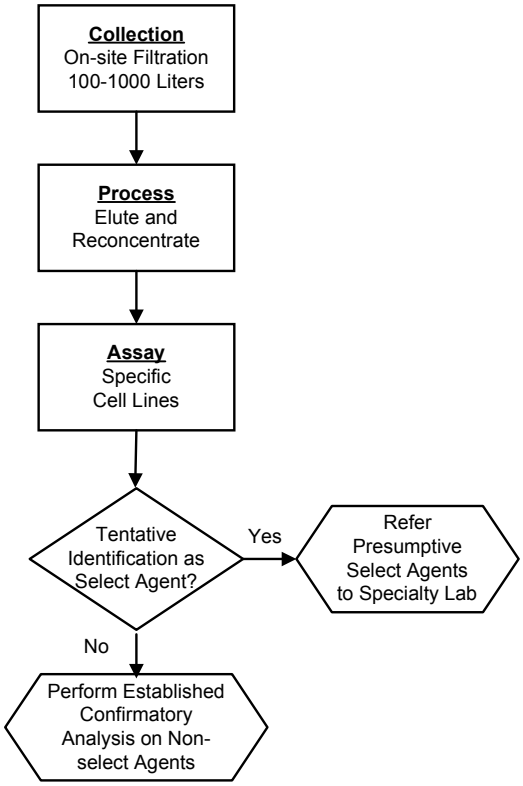


Figure 4-11. Virological Analysis with Established Techniques

8.3.3 Parasitological Analysis with Established Techniques

Established sample collection techniques for protozoa in water consist of obtaining a grab sample of 10 liters or alternatively, performing filtration in the field (EPA Method 1623, http://www.epa.gov/nerlcwww/). The grab sample or the filter is sent to an environmental laboratory for processing. In the laboratory, protozoa retained by the filter are eluted, concentrated by centrifugation and purified by immunomagnetic separation (IMS). *Giardia* cysts and *Cryptosporidium* oocysts are identified and counted by the indirect fluorescent assay with an epifluorescence (or UV) microscope (Figure 4-12).

Exploratory techniques such as PCR can be readily applied to cysts and oocysts purified by the immunomagnetic separation step of Method 1623. In addition, the infectivity of *Cryptosporidium* oocysts can also be determined by cell culture infectivity after IMS purification.

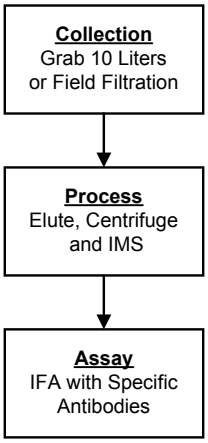


Figure 4-12. Parasitological Analysis with Established Techniques

8.4 Method for Sample Collection, Field Processing, and Laboratory Analysis for Unknown Microbial Contaminants

Sample collection, processing, and analysis of an unknown microbial contaminant are inherently linked because the procedure relies on the use of an ultrafiltration device in the field (see Module 3). Together, the collection, processing, and analysis may be considered to constitute a method for unknown microbial contaminants, and the individual parts are discussed below. This method, including a suitable ultrafiltration device, is currently under development.

8.4.1 Sample Collection and Concentration for Unknown Microbials

Ultrafiltration is a size exclusion process, and particles larger than the molecular weight cut-off (MWCO) of the membrane, are concentrated in the *retentate* and separated from the *filtrate*. Ultrafiltration can concentrate viruses, bacteria, spores or parasites as long as the organisms are larger than the MWCO of the membrane selected. Thus, the method is suitable for sampling water with an unknown biological contaminant. Also, ultrafiltration of water samples can be used to concentrate some biotoxins if the MWCO of the selected membrane is sufficiently small.

The overall procedure, illustrated in Figure 4-13, consists of concentrating large (100 liters or more) volumes of water by cross-flow disposable hollow fiber ultrafiltration cartridges, and subsequently recovering pathogens and other concentrated microorganism and particles in the filter retentate. The recovered retentate is referred to as the *field sample concentrate*. The field sample concentrate will be separated into three aliquots. Ultrafiltration of 100 liters or more of finished (e.g., tap) water will result in a retentate volume of approximately 250 ml. A small aliquot ($1/20^{th}$ of the field sample concentrate) can be used for field screening (Section 8.4.2). Approximately one half of the field sample concentrate can be used for presumptive PCR testing (Section 8.4.3). The remainder can be used for confirmatory culture techniques (Section 8.4.4). The reason for dividing the field sample concentrate is that some of the reagents for molecular analysis that may be added in the field will essentially inactivate any microbes present in the sample.

The basic elements of an ultrafiltration field concentration apparatus (Figure 4-14) consist of an input reservoir for sample collection, a peristaltic pump, a cross-flow hollow fiber membrane cartridge, a retentate reservoir and a filtrate reservoir. Operating the unit in cross-flow mode is preferable because "caking" or fouling of membranes is reduced. Non-reactive membranes are preferable, such as polysulfone or low protein binding membranes.

Sample filtration is conducted by recirculating water (necessary to maintain cross-flow conditions) with a 5-10 PSI differential between the input and retentate pressure. The pressure differential forces water through the hollow fiber membrane which retains particles (including microbes) larger than the membrane pores in an increasingly concentrated liquid retentate volume. The water containing particles that passes through the filter is known as filtrate. The volume of the retentate is reduced to approximately 250 ml by recirculating the concentrated sample through the smaller retentate loop for capture in the retentate reservoir. The retentate reservoir vessel can be used for sample shipping if necessary. The sample retentate can also be recovered by backflushing (reversing the flow through of the hollow fiber membrane cartridge).

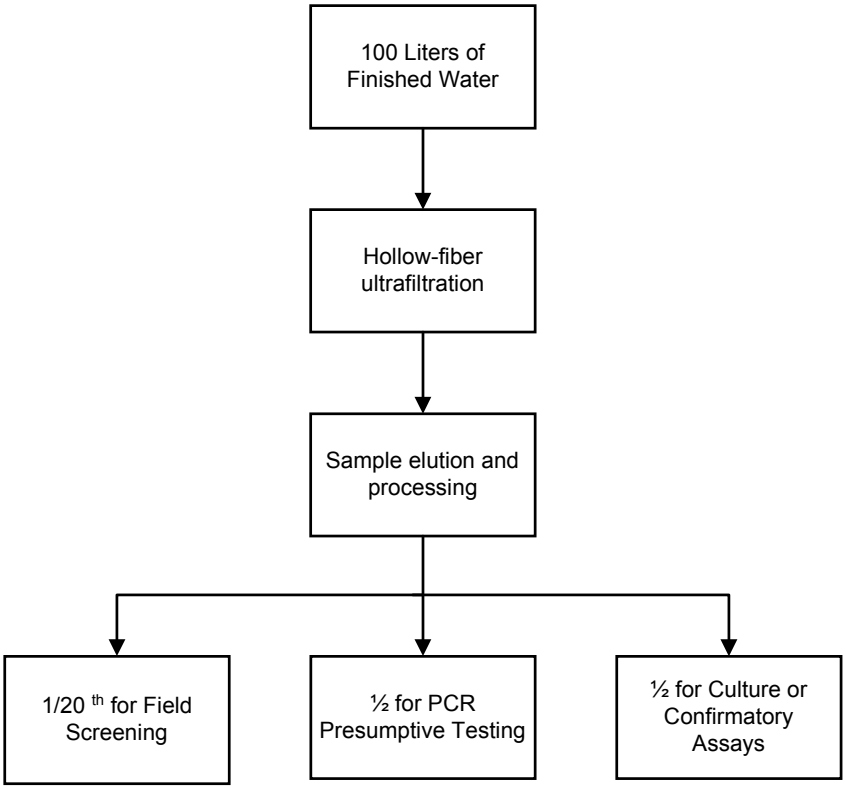


Figure 4-13. Sample Collection and Processing for Unknown Microbial Contaminants

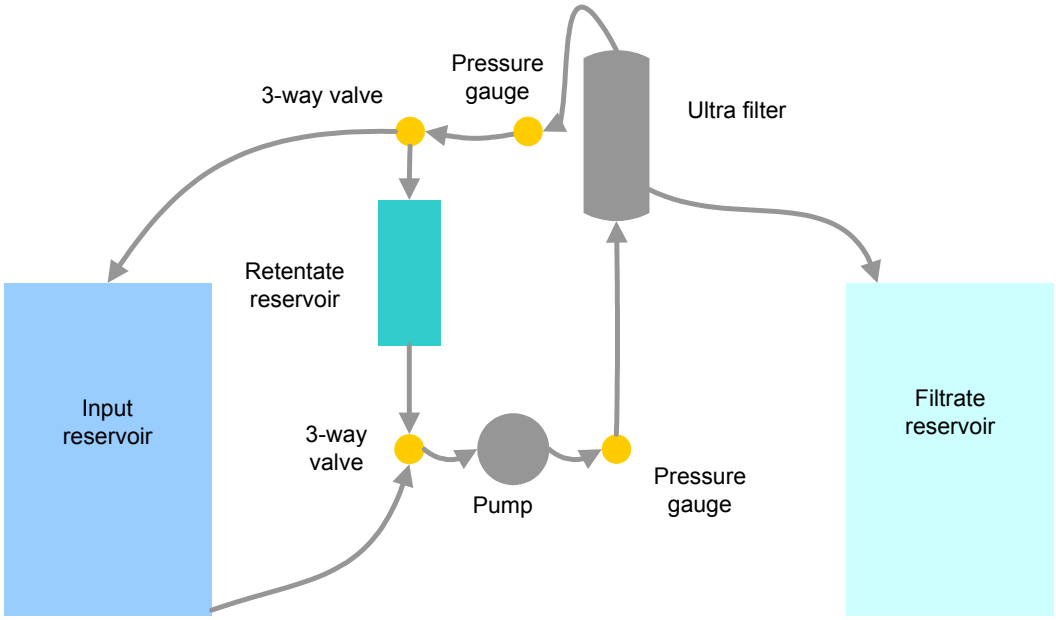


Figure 4-14. Field Concentrator Schematic

8.4.2 Field Screening and Processing of Sample

Field processing of the small aliquot of the field sample concentrate from the ultrafiltration concentrator consists of field screening for microbial contaminants (Figure 4-15), which also is a component of site characterization (see Module 3). This field screening, in turn, may result in rapid actions to prevent further adverse consequences to safety and health of the samplers, laboratory personnel, and the general public. It is important to remember that both field screening by equipment and field test assays have only limited use, and any results need to be confirmed by additional laboratory testing.

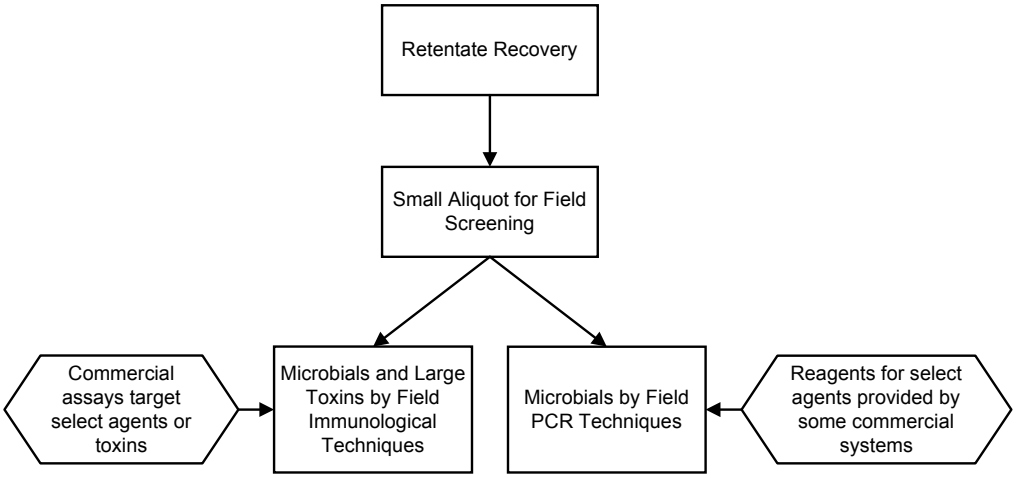


Figure 4-15. Field Processing for Microbials

Field screening equipment encompasses a wide range of technologies including lateral flow chromatography, antibody identification, hand-held or field deployable PCR based assays, and others (Table 4-15). The specific technology chosen will affect the interpretation of field results. The Office of Justice Programs of the Department of Justice (DOJ) has provided a list of available technologies for field screening (http://www.ojp.usdoj.gov/nij/pubs-sum/190747.htm). (The DOJ document contains neither an endorsement of any specific technology nor an evaluation of their performance.)

Many of the available field screening assay tests (Table 4-15) are less sensitive than laboratory-based assays by perhaps several orders of magnitude, and thus there is a potential for false negative results. Due to possible cross-reactivity, these technologies may also lead to false positive reactions. The results of field screening should be used as part of a threat characterization process and not as part of a conclusive analytical procedure.

Table 4-15. Exploratory Field Screening Techniques for Waterborne Contaminants and Select Agents

Pathogen (general class)	Organism	Screening Technique*	Commercial Sources
Waterborne Contaminants			
Bacteria	*Campylobacter* spp. *E. coli* 0157:H7 *Salmonella* spp.	PCR PCR PCR	Yes
Protozoa		TBD	TBD
Viruses		TBD	TBD
Select Agents			
Spores	*Bacillus anthracis* *Clostridium botulinum A*	PCR and Smart tickets PCR	Yes
Bacteria	*Brucella* spp. *Francisella tularensis* *Yersinia pestis*	PCR	Yes
Protozoa		TBD	TBD
Viruses		TBD	TBD

* TBD = to be determined

8.4.3 Presumptive Testing for Microbials with Exploratory PCR Techniques

For presumptive testing of the field sample concentrate from the ultrafiltration concentrator, exploratory techniques such as PCR testing may be utilized as a means to obtain faster presumptive results for critical samples. These presumptive results may be used during the threat evaluation (Module 2) and site characterization (Module 3) procedures. Although PCR techniques are widely used in the clinical and medical fields, these techniques are still regarded as exploratory in the field of environmental microbiology. PCR has three main benefits in a presumptive test: 1) results can be obtained faster; 2) multiple targets can be assayed in a short period of time; and 3) cultural methods are not available yet for some microbial contaminants of interest. Another advantage of PCR testing is that samples could be analyzed concurrently with the conventional established methods. Table 4-16 lists PCR techniques for the biological contaminants of concern.

Table 4-16. Exploratory Analytical Techniques for Presumptive Testing of Waterborne Contaminants and Select Agents

Pathogen general class	Organism	Presumptive Testing Technique	Confirmation
Bacteria	*Campylobacter* spp.	PCR	Probe or sequencing
	E. coli 0157:H7	PCR	Probe or sequencing
	Salmonella spp.	PCR	Probe or sequencing
	Shigella spp.	PCR	Probe or sequencing
	Vibrio cholerae	PCR	Probe or sequencing
Protozoa	*Cryptosporidium parvum*	PCR	Probe or sequencing
	Giardia intestinalis	PCR	Probe or sequencing
	Entamoeba histolytica	PCR	Probe or sequencing
	Toxoplasma gondii	PCR	Probe or sequencing
Viruses	Enteroviruses	RT-PCR	Probe or sequencing
	Hepatitis A	RT-PCR	Probe or sequencing
	Hepatitis E	RT-PCR	Probe or sequencing
	Noroviruses	RT-PCR	Probe or sequencing
	Rotavirus	RT-PCR	Probe or sequencing
Spores	*Bacillus anthracis*	PCR	Probe or sequencing
	Clostridium botulinum A	PCR	Probe or sequencing
Bacteria	*Brucella* spp.	PCR	Probe or sequencing
	Burkholderia pseudomallerei	PCR	Probe or sequencing
	Francisella tularensis	PCR	Probe or sequencing
	Yersinia pestis	PCR	Probe or sequencing
Rickettsia	*Coxiella burnetti*	PCR	Probe or sequencing
Viruses	Variola*	PCR	Probe or sequencing
	VEE*	RT-PCR	Probe or sequencing
	VHF*	RT-PCR	Probe or sequencing

*These viruses are not considered to pose a major threat in water

Protozoa and bacteria in the field sample concentrate are further concentrated by centrifugation of the sample in the laboratory (Figure 4-16). Possible spores, bacteria or protozoa in the sample are recovered in the pellet whereas viruses will be retained in the supernatant. DNA from spores, vegetative bacteria or protozoa is extracted from the pellet. DNA extraction kits designed to remove co-contaminants from environmental samples are more desirable since ultrafiltration will tend to concentrate soil-derived PCR inhibitors (e.g., humic and fulvic acids). The supernatant is further concentrated by a second phase of ultrafiltration. RNA-containing viruses are the anticipated target in a water sample; thus, a procedure for RNA extraction and purification is to be followed. The purified RNA is used for reverse transcriptase-PCR (RT-PCR) to desired viral RNA targets.

Primers and probes for PCR presumptive testing for waterborne and non-select agents may be obtained from the scientific literature. Some commercial vendors provide primers and probes for select agents, although these are not necessarily utilized by the LRN for its analysis. The LRN system utilizes a restricted set of primers and probes for detection of select agents. (If a DNA virus, such as variola, is strongly suspected, a different technique will be necessary for extraction and purification of its DNA, although variola is not considered a priority threat in water).

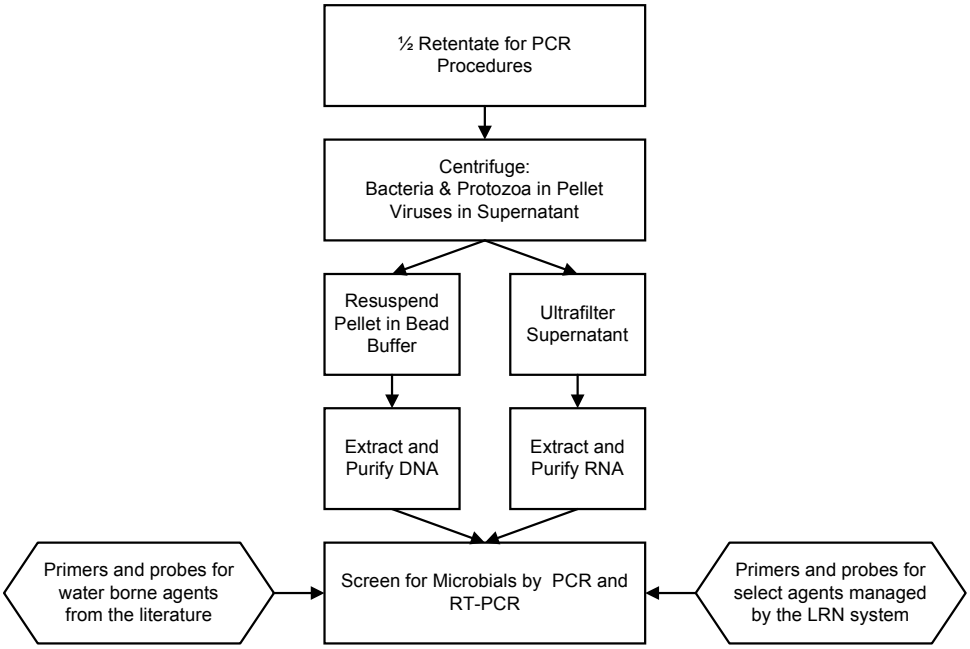


Figure 4-16. Sample Processing for Exploratory PCR Presumptive Testing

8.4.4 Confirmatory Testing for Microbials by Culture and Conventional Assays

Processing of the field sample concentrate for culture assays (Figure 4-17) consists of an initial centrifugation step to further concentrate bacteria (vegetative cells and spores) and protozoa in the sample. Bacteria and protozoa will be concentrated in the pellet, and viruses will remain in the supernatant. Protozoa are separated from the bacteria by IMS. Bacteria will remain in the IMS supernatant (liquid phase) and the protozoa will be concentrated with the beads (solid phase). Viruses are further concentrated for cell culture analysis. Table 4-17 lists established confirmatory analytical techniques for waterborne and select agents.

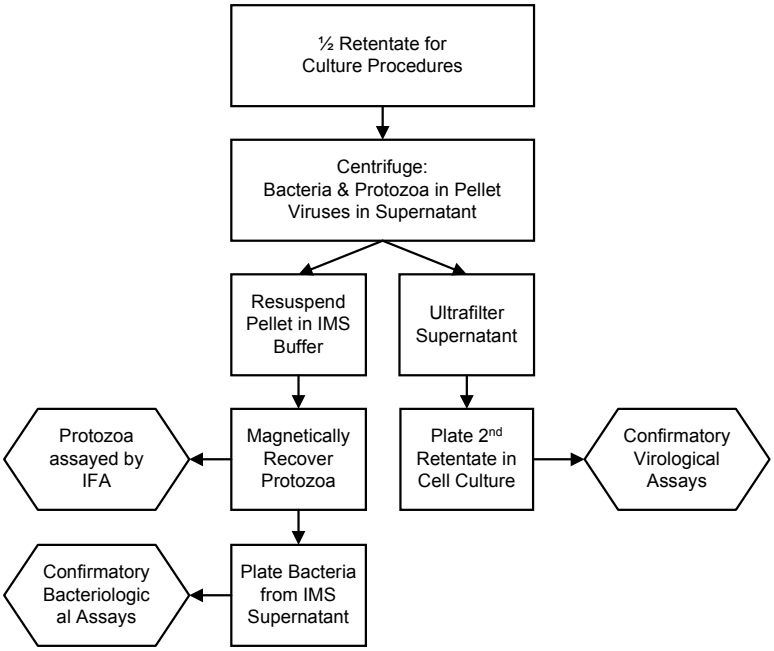


Figure 4-17. Sample Processing for Confirmatory Microbiological Assays

Table 4-17. Established Confirmatory Analytical Techniques for Waterborne Contaminants and Select Agents

Pathogen (general class)	Organism	Confirmatory Techniques	Additional Exploratory Techniques
Waterborne Contaminants			
Bacteria	*Campylobacter* spp. E. coli 0157:H7 *Salmonella* spp. *Shigella* spp. *Vibrio cholerae*	Biochemical and Serological Tests	PCR and Sequencing
Protozoa	*Cryptosporidium parvum* *Giardia intestinalis* *Entamoeba histolytica* *Toxoplasma gondii*	IFA and Microscopy	PCR and Sequencing
Viruses	Enteroviruses Hepatitis A Hepatitis E Noroviruses Rotavirus	Plaque neutralization N/A N/A N/A IFA	RT-PCR and Sequencing IFA, RIFA, PCR RT-PCR and Sequencing RT-PCR and Sequencing RT-PCR and Sequencing
Select Agents			
Spores	*Bacillus anthracis* *Clostridium botulinum* A	Biochemical and Serological Tests	PCR and Sequencing
Bacteria	*Brucella* spp. *Burkholderia pseudomallerei* *Francisella tularensis* *Yersinia pestis*	Biochemical and Serological Tests	PCR and Sequencing
Rickettsia	*Coxiella burnetti*	Biochemical and Serological Tests	
Viruses	Variola VEE, VHF	TBD	PCR and Sequencing PCR and Sequencing

The procedures outlined in this section are intended for use in water samples where select agents are suspected to be present, thus these procedures should be performed in microbiology laboratories that use appropriate Biological Safety Level practices. For all suspected pathogens, refer to the CDC publication "Biosafety in Microbiological and Biomedical Laboratories," 4th edition (HHS Publication No. 93-8395, http://www.cdc.gov/od/ohs/pdffiles/4th%20BMBL.pdf). Some BSL requirements are summarized below, broken out by pathogen class.

Bacterial assays

Pathogenic enteric bacteria can be handled in an environmental BSL-2 laboratory. Nonetheless, select agents should only be analyzed for presumptive identification by laboratories approved for presumptive identification of select agents. *Brucella* spp. (BSL-3), *Burkholderia mallei* (BSL-2), *B. pseudomallei* (BSL-2), *Yersinia pestis* (BSL-2), and *Francisella tularensis* (BSL-3) are highly infectious and have caused laboratory-acquired infections. Because of the highly infectious nature of these pathogens, consultation with a state public health laboratory is recommended if any of these are suspected in a sample.

Protozoa

The solid phase of the IMS procedure is further processed by EPA Method 1623 for IFA identification of *Cryptosporidium* and *Giardia*. The protozoa *Cryptosporidium parvum*, *Giardia intestinalis*, *Entamoeba histolytica*, and *Toxoplasma gondii* can be handled in an environmental BSL-2 laboratory.

Viruses

Viruses in the supernatant from the centrifugation step above are further concentrated by a second ultrafiltration to reduce the assay volume for cell culture analysis. Pathogenic enteric viruses can be handled in an environmental BSL-2 laboratory. Nonetheless, select agents should only be analyzed for presumptive identification by laboratories approved for presumptive identification of select agents. Variola (BSL-3), VEE (BSL-3) and VHF (BSL-4) are highly infectious, and suspected samples should be referred to an LRN laboratory. Because multiple virus targets are pursued, the sample is likely to be inoculated onto more than one cell line.

Public health laboratories primarily use tube cultures of mammalian cells which are amenable only for small inoculation volumes. However, tube culture is a well established method and fairly efficient for virus detection. Infectious viruses are amplified in the receptive cells and are used as the source of infectious material for subsequent identification and confirmation assays. Identification and analytical confirmation consists of neutralization assays with specific antisera. PCR and sequencing of positive samples is also an exploratory technique that could be used to further identify and characterize the isolated virus. DNA sequencing is used for fingerprinting studies and for definitive identification of pathogens.

9 References and Resources

References and information cited or used to develop this module are listed below. The URLs of several sources are cited throughout the text. These URLs were correct at the time of the preparation of this document. If the document is no longer available at the URL provided, please search the sponsoring organization's Web site or the World Wide Web for alternate sources. A copy of referenced documents may also be provided on the CD version of this module, although readers should consult the referenced URL for the latest version.

AOAC. 2003a. "Home of AOAC International, The Cornerstone for Online Analytical Methods" http://www.aoac.org.

AOAC. 2003b. "Rapid Test Kits Test Kit Database" http://www.aoac.org/testkits/TKDATA2.HTM.

ASTM, 2003, "Standards Worldwide – ASTM International" http://www.astm.org.

CDC. 1999. "Biosafety in Microbiological and Biomedical Laboratories" http://www.cdc.gov/od/ohs/pdffiles/4th%20BMBL.pdf.

CDC. 2002a. "Summary of the Laboratory Response Network" http://www.cdc.gov/cic/functions-specs/function4Docs/nLRNvision-summary.doc.

CDC. 2002b. "Possession, Use, and Transfer of Select Agents and Toxins: Interim Final Rule; Department of Health and Human Services, 42 CFR Part 1003; December 13, 2002" http://www.cdc.gov/od/sap/docs/42cfr73.pdf.

CDC. 2003a. "What to do in an Emergency" http://www.bt.cdc.gov/emcontact/index.asp.

CDC. 2003b. "Biological Agents-Diseases Public Health Emergency" http://www.bt.cdc.gov/Agent/agentlist.asp.

CDC. 2003c. "Office of the Director--Select Agent Program" http://www.cdc.gov/od/sap.

CDC. 2003d. "Office of the Director--Select Agent Program FAQ" http://www.cdc.gov/od/sap/faq.htm.

CDC. 2003e. "Office of the Director--Select Agent Program Additional Resource Material" http://www.cdc.gov/od/sap/addres.htm.

CDC. 2003f. "Summary of Biosafety Level-1&2 for Infectious Agents" http://www.bt.cdc.gov/documents/PPTResponse/table3abiosafety.pdf.

CDC. 2003f. "List of Select Biological Agents" http://www.cdc.gov/od/sap/docs/salist.pdf.

Clesceri, Lenore S., Arnold E. Greenberg, Andrew D. Eaton, Editors. 1999. Standard Methods for the Examination of Water and Wastewater, 20th edition (January 1999). A joint publication of the Water Environment Federation, the American Water Works Association, and the American Public Health Association, Washington, DC. ISBN 0-87553-235-7

CWC. 2003a. "CWC Regulations – Supplement No. 1 to Part 712 –Schedule 1 Chemicals" http://www.cwc.gov/Regulations/cfr-15/part-712-s1_html See also http://www.cwc.gov/Industry_Outreach/Publications/002/cwc-b0001_html http://www.cwc.gov/Regulations/cfr-15/index_html.

CWC. 2003b. "The Chemical Weapons Convention – A Quick Guide, CWC-002" http://www.cwc.gov/Industry_Outreach/Publications/002/cwc-b0001_html.

CWC. 2003c. "CWC Regulations – Supplement No. 1 to Part 713 –Schedule 2 Chemicals" http://www.cwc.gov/Regulations/cfr-15/part-713-s1_html.

CWC. 2003d. "CWC Regulations – Supplement No. 1 to Part 714 –Schedule 3 Chemicals" http://www.cwc.gov/Regulations/cfr-15/part-714-s1_html.

DOJ/NIJ. 2001. "An Introduction to Biological Agent Detection Equipment for Emergency First Responders, NIJ Guide 101-00, December 2001" http://www.ojp.usdoj.gov/nij/pubs-sum/190747.htm.

DOT. 2003. "Welcome to the Hazmat Safety Homepage" http://hazmat.dot.gov/.

EPA and USGS. 2003. "National Environmental Methods Index" http://www.nemi.gov.

EPA. 2000. "EPA Radiological Emergency Response Plan" http://www.epa.gov/radiation/rert/docs/rerp-1-00.pdf.

EPA. 2002a. "EPA Manual of Manuals – Laboratory Analytical Methods Manuals" http://www.epa.gov/nerlcwww/methmans.html.

EPA. 2002b. "Setting Guidelines to Protect the Public – Information Home (EPA's Radiation Protection Program Information)" http://www.epa.gov/radiation/docs/readytorespond/ready3.htm.

EPA. 2002c. "EPA's Radiation Protection Program" http://www.epa.gov/radiation/marlap/.

EPA. 2003a. "EPA's Radiation Protection Program Information" http://www.epa.gov/radiation/programs.htm - er.

EPA. 2003b. "EPA Quality System – Information for non-EPA Organizations" *http://www.epa.gov/quality1/exmural.html#genreqts.*

EPA. 2003c. "EPA Environmental Technology Verification Home" http://www.epa.gov/etv/.

EPA. 2003d. "EPA Analytical Methods for Drinking Water and Analytical Methods Developed by the Office of Ground Water and Drinking Water" http://www.epa.gov/safewater/methods/sourcalt.html.

EPA. 2003e. "EPA Methods from the Office of Research and Development" http://www.epa.gov/nerlcwww/ordmeth.htm.

EPA. 2003f. "Test Methods SW-846 On-line" http://www.epa.gov/epaoswer/hazwaste/test/main.htm.

EPA. 2003g. "CFR Title 40 Protection of Environment" http://www.epa.gov/docs/epacfr40/chapt-I.info/subch-D.htm.

EPA. 2003h. "EPA Ground Water and Drinking Water Drinking Water Contaminant Candidate List" http://www.epa.gov/safewater/ccl/cclfs.html.

EPA. 2003i. "EPA Unregulated Contaminant Monitoring Regulation" http://www.epa.gov/safewater/standard/ucmr/main.html.

EPA. 2003j. "New Test Methods On-line" http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

EPA. 2003k. "ETV – Verifications" http://www.epa.gov/etv/verifications/.

EPA. 2003l. "EPA Microbiology Home Page" http://www.epa.gov/nerlcwww/.

ERT. 2003. "ERT Health and Safety" http://www.ertresponse.com/health_safety/index.htm.

FEMA. 2003. "FEMA Radiological Emergency Preparedness Program" http://www.fema.gov/rrr/rep/index.shtm.

FJC. 2000. "Reference Manual Scientific Evidence, Second Edition" http://www.fjc.gov/public/pdf.nsf/lookup/sciman00.pdf/$file/sciman00.pdf.

ISO. 2003. "ISO – International Standard for Organization" http://www.iso.org.

NIOSH. 2003. "NIOSH – National Personal Protective Technology Laboratory" http://www.cdc.gov/niosh/npptl/default.html.

NIST. 2002. "AMDIS Download Page" http://chemdata.nist.gov/mass-spc/amdis/.

NRT. 1996. "Federal Register – FEMA Federal Radiological Emergency Response Plan" http://www.nrt.org/production/nrt/home.nsf/0/5c23c5d58074d6e48525660c005b56b5?OpenDocument.

OSHA. 2002. "Safety and Health Topics Personal Protective Equipment" http://www.osha.gov/SLTC/personalprotectiveequipment/index.html.

OSHA. 2003a. "OSHA e-HASP Software –Version 1.0, September 2003" http://www.osha.gov/dts/osta/oshasoft/ehasp/.

OSHA. 2003b. "Occupational Safety and Health Administration Homepage" http://www.osha.gov.

UNESCO. 1995. "UNESCO's Documentary Resources—Manual on Harmful Marine Microalgae" http://unesdoc.unesco.org/images/0012/001220/122021eo.pdf.

US Army. 2002. "Toxic Chemical Agent Safety Standards" http://www.usapa.army.mil/pdffiles/p385_61.pdf.

US Coast Guard. 2001. "Chemical Hazards Response Information System" http://www.chrismanual.com.

USDA. 2003a. "Animal and Plant Health Inspection Service" http://www.aphis.usda.gov.

USGS. 2003. "Methods and Data Comparability Board Home Page" http://wi.water.usgs.gov/pmethods/.

10 Appendices

10.1 Chemicals that appear in CWC Schedules

Table 4-18. List of chemicals that appear in CWC Schedules 1, 2, and 3 (http://www.cwc.gov/Regulations/cfr-15/index_html)

Schedule 1 Chemical Agents	Schedule 2 Chemical Agents	Schedule 3 Chemical Agents
O-Alkyl (≤C10, incl. cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr)-phosphonofluoridates (e.g. Sarin: O-Isopropyl methylphoshonofluoridate Soman: O-Pinacolyl methylphosphonofluoridate)	Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate and corresponding alkylated or protonated salts	Phosgene: carbonyl dichloride
O-Alkyl (≤C10, incl. cycloalkyl)N,N-dialkyl (Me, Et, n-Pr or I-Pr)-phosphoramidocyanidates (e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate)	PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene	Cyanogen chloride
O-alkyl (H or ≤ C10, incl. cycloalkyl)S-2-dialkyl (Me, Et, n-Pr or I-Pr)-aminoethyl alkyl (Me, Et, n-Pr or I-Pr) phosphonothiolates and corresponding alkylated or protonated salts (e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate)	BZ: 3-Quinuclidinyl benzilate	Hydrogen cyanide
Sulfur mustards: 2-Chloroethylchloromethylsulfide Mustard gas: Bis(2-chloroethyl)sulfide Bis(2-chloroethylthio)methane Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane 1,3-Bis(2-chloroethylthio)-n-propane 1,4-Bis(2-chloroethylthio)-n-butane 1,5-Bis(2-chloroethylthio)-n-pentane Bis(2-chloroethylthiomethyl)ether O-Mustard: Bis(2-chloroethylthioethyl)ether	Chemicals, except for those listed in Schedule 1, containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, e.g., Methylphosphonyl dichloride Dimethyl methylphosphonate Exemption: Fonofos: O-Ethyl S-phenyl ethylphosphonothiolothionate	Chloropicrin: trichloronitromethane
Lewisites: Lewisite 1:2-Chlorovinyldichloroarsine Lewisite 2:Bis(2-chlorovinyl)chloroarsine Lewisite 3:Tris (2-chlorovinyl)arsine	N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides	Phosphorus oxychloride
Nitrogen mustards:	Dialkyl (Me, Et, n-Pr or i-Pr) N,N-	Phosphorus trichloride

Schedule 1 Chemical Agents	Schedule 2 Chemical Agents	Schedule 3 Chemical Agents
HN1: Bis(2-chloroethyl)ethylamine HN2: Bis(2-chloroethyl)methylamine HN3: Tris(2-chloroethyl)amine	dialkyl (Me, Et, n-Pr or i-Pr)-phosphoramidates	
Saxitoxin	Arsenic trichloride	Phosphorus pentachloride
Ricin	2,2-Diphenyl-2-hydroxyacetic acid	Trimethyl phosphite
Alkyl (Me, Et, n-Pr or I-Pr)phoshonyldifluorides e.g., DF:Methylphosphonyldifluoride	Quinuclidine-3-ol	Triethyl phosphite
O-Alkyl(incl. Cycloalkyl)O-2-dialkyl (Me, Et, n-Pr or I-Pr)-aminoethyl alkyl (Me, Et, n-Pr or I-Pr) phosphonites and corresponding alkylated or protonated salts e.g., QL: O-Ethyl O-2-diisopropylaminoethyl methylphosphonite	N,N-Dialkyl (Me, Et, n-Pr or I-Pr) aminoethyl-2-chlorides and corresponding protonated salts	Dimethyl phosphite
Chlorosarin: O-Isopropyl methylphosphonochloridate	-Dialkyl (Me, Et, n-Pr or I-Pr) noethane-2-ols and corresponding onated salts mption: N,N-Dimethylaminoethanol corresponding protonated salts N,N-hylaminoethanol and corresponding onated salts	Diethyl phosphite
Chlorosoman: O-Pinacolyl methylphosphonochloridate	N,N-Dialkyl (Me, Et, n-Pr or I-Pr) aminoethane-2-thiols and corresponding protonated salts	Sulfur monochloride
	Thiodiglycol: Bis(2-hydroxyethyl) sulfide	Sulfur dichloride
	Pinacolyl alcohol: 3,3-Dimethylbutane-2-ol	Thionyl chloride
		Ethyldiethanolamine
		Methyldiethanolamine
		Triethanolamine

10.2 Methods Used for the Basic Screen

Table 4-19. Titles of methods used in Table 4-3 for the basic screen. (See Table 4-2 for information on how to obtain these methods.)

EPA Method number	Title
Drinking water methods	
200.7, May 1994, Revision 4.4*	Trace Elements in Water, Solids, and Biosolids by Inductively Coupled Plasma-Atomic Emission Spectrometry
200.8, May 1994, Revision 5.4*	Determination Of Trace Elements In Waters And Wastes By Inductively Coupled Plasma Mass Spectrometry
200.9, May 1994, Revision 2.2*	Trace Elements in Water, Solids, and Biosolids by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry
245.1, May 1994, Revision 3.0*	Mercury (Manual Cold Vapor Technique)
245.2, March 1983*	Mercury (Automated Cold Vapor Technique)
335.2, March 1983	Cyanide, Total (Titrimetric; Spectrophotometric)
335.3, March 1983	Cyanide, Total (Colorimetric, Automated UV)
335.4, March 1983	Cyanide, Total (Colorimetric, Semi-automated UV)
502.2, 1995, Revision 2.1*	Volatile Organic Compounds in Water By Purge And Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series
524.2, 1995, Revision 4.1*	Measurement Of Purgeable Organic Compounds In Water By Capillary Column Gas Chromatography/mass Spectrometry
525.2, 1995, Revision 2.0*	Determination of Organic Compounds in Drinking Water By Liquid-solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry
531.1, 1995, Revision 3.1* 531.2, September 2001, Revision 1.0	Measurement of N-methylcarbamoyloximes and N-methyl-carbamates in Water by Direct Aqueous Injection HPLC with Post-Column Derivatization
549.2, 1997, Revision 1.0*	Determination of Diquat and Paraquat in Drinking Water by Liquid-Solid Extraction and High Performance Liquid Chromatography with Ultraviolet Detection
900, August 1980*	Proscribed Procedures for the Determination of Radioactivity in Water
SW-846 methods	
3535A, January 1998, Revision 1	Solid-Phase Extraction (SPE) [preparation technique for 8270D]
5030B, December 1996, Revision 2	Purge-and-Trap for Aqueous Samples
8021B, December 1996, Revision 2	Aromatic and Halogenated Volatiles by Gas Chromatography Using Photoionization and/or Electrolytic Conductivity Detectors
8260B, December 1996, Revision 2	Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
8270D, January 1998, Revision 4	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
1998	

* These methods are approved at 40 CFR Part 141 for regulatory compliance monitoring of drinking water.

10.3 Analyte Lists for Basic Screen

Table 4-20. Analyte Lists Corresponding to Table 4-3.
Note: Laboratories may recognize these as commercially available standard mixes or combinations thereof. This does not imply endorsement of any company, product, or service. The standard mixes do not necessarily include all analytes that the method is capable of determining. For example, in list B, only 90 analytes are included, although commercially available mixes could be selected to encompass more than 150 compounds. Laboratories should be encouraged to include as many analytes as possible in the standards mix to increase the breadth of the screen. Because the analyte lists are intended for the basic screen, which is designed to produce defensible results, laboratories may wish to modify the analyte lists to reflect their accreditations and certifications. However, additional analytes may become part of the expanded screen, so laboratories may wish to include those anyway. Analytes added to those listed must meet the same QC acceptance criteria and be part of the overall quality system in the laboratory, so that the added analytes will be as defensible as those listed.

The exclusion or inclusion of an analyte in the lists in this table does not reflect its potential hazard as a water contaminant. Rather, these analytes were chosen for the convenience of commercial availability of standard mixes. In practice, site-specific plans and situations may be used (and are encouraged) to modify these lists.

Analyte Lists Corresponding to Table 4-3							
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1,1,1,2-Tetrachloroethane	2,2',3,3',4,4',6-Heptachlorobiphenyl	Aldicarb	diquat	arsenic	mercury	free cyanide (see method)	cesium-137
1,1,1-Trichloroethane	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	aldicarb sulfone	paraquat	cadmium			iridium-192
1,1,2,2-Tetrachloroethane	2,2',3',4,6-Pentachlorobiphenyl	aldicarb sulfoxide		chromium			cobalt-60
1,1,2-Trichloroethane	2,2',4,4',5,6'-Hexachlorobiphenyl	carbofuran		cobalt			strontium-90
1,1-Dichloroethane	2,2',4,4'-Tetrachlorobiphenyl	3-Hydroxycarbofuran		copper			
1,1-Dichloroethene	2,3-Dichlorobiphenyl	methiocarb		lead			
1,1-Dichloropropene	2,4,5-Trichlorobiphenyl	methomyl		mercury			
1,2,3-Trichlorobenzene	2,4-Dinitrotoluene	Oxamyl					
1,2,3-Trichloropropane	2,6-Dinitrotoluene	Propoxur					
1,2,4-Trichlorobenzene	2-Chlorobiphenyl	Sevin (carbaryl)					
1,2,4-Trimethylbenzene	a-BHC						
1,2-Dibromo-3-chloropropane	Acenaphthylene						
1,2-Dibromoethane	a-Chlordane						
1,2-Dichlorobenzene	Alachlor						
1,2-Dichloroethane	Aldrin						
1,2-Dichloropropane	alpha-Chlordane						
1,3,5-Trimethylbenzene	Anthracene						

Analyte Lists Corresponding to Table 4-3							
A	B	C	D	E	F	G	H
1,3-Dichlorobenzene	Atrazine						
1,3-Dichloropropane	Azinphos methyl						
1,4-Dichlorobenzene	b-BHC						
2,2-Dichloropropane	Benz(a)anthracene						
2-Chlorotoluene	Benzo(a)pyrene						
2-Nitropropane	Benzo(a)pyrene						
4-Chlorotoluene	Benzo(b)fluoranthene						
acrylonitrile	Benzo(g,h,i)perylene						
allyl chloride	Benzo(k)fluoranthene						
Benzene	bis(2-Ethylhexyl)adipate						
Bromobenzene	bis(2-Ethylhexyl)phthalate						
Bromochloromethane	Bolstar						
Bromodichloromethane	Butachlor						
Bromoform	Butylbenzylphthalate						
Bromomethane	Chlorobenzilate						
Butyl chloride	Chloroneb						
Carbon disulfide	Chlorothalonil						
Carbon tetrachloride	Chlorpyrifos						
Chloroacetonitrile	Chrysene						
Chlorobenzene	cis-Permethrin						
Chloroethane	Coumaphos						
Chloroform	Cyanazine						
Chloromethane	Dacthal						
Cis-1,2-Dichloroethene	d-BHC						
Cis-1,3-Dichloropropene	Demeton (mixed isomers)						
Dibromochloromethane	Diazinon						
Dibromomethane	Dibenz(a,h)anthracene						
Dichlorodifluoromethane	Dichlorvos						
Diethyl ether	Dieldrin						
Ethyl methacrylate	Diethyl phthalate						
Ethylbenzene	Dimethyl phthalate						
Hexachlorobutadiene	Di-n-butyl phthalate						
Hexachloroethane	Disulfoton						
Isopropylbenzene	Endosulfan I						
Methacrylonitrile	Endosulfan II						
methanol (solvent)	Endosulfan sulfate						
Methyl acrylate	Endrin						
Methyl methacrylate	Endrin aldehyde						
Methyl tert-butyl ether	Ethoprop						
Methylene chloride	Etridiazole						
m-Xylene	Fensulfothion						
Naphthalene	Fenthion						
n-Butylbenzene	Fluorene						
Nitrobenzene	g-BHC						

Analyte Lists Corresponding to Table 4-3							
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
n-Propylbenzene	g-Chlordane						
o-Xylene	Heptachlor						
Pentachloroethane	Heptachlor epoxide (Isomer B)						
p-Isopropyltoluene	Hexachlorobenzene						
Propionitrile	Hexachlorocyclopentadiene						
p-Xylene	Indeno(1,2,3-cd)pyrene						
sec-Butylbenzene	Lindane						
Styrene	Merphos						
tert-Butylbenzene	Methoxychlor						
Tetrachloroethene	Methyl parathion						
Tetrahydrofuran	Metolachlor						
Toluene	Metribuzin						
trans-1,2-Dichloroethene	Mevinphos						
trans-1,3-Dichloropropene	Naled						
trans-1,4-Dichloro-2-butene	p,p'-DDD						
Trichloroethene	p,p'-DDE						
Trichlorofluoromethane	p,p'-DDT						
Vinyl chloride	Pentachlorophenol						
	Phenanthrene						
	Phorate						
	Propachlor						
	Pyrene						
	Ronnel						
	Simazine						
	Stirophos						
	Tokuthion						
	trans-Nonachlor						
	Trichloronate						

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-004
www.epa.gov/safewater/security
December 2003

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

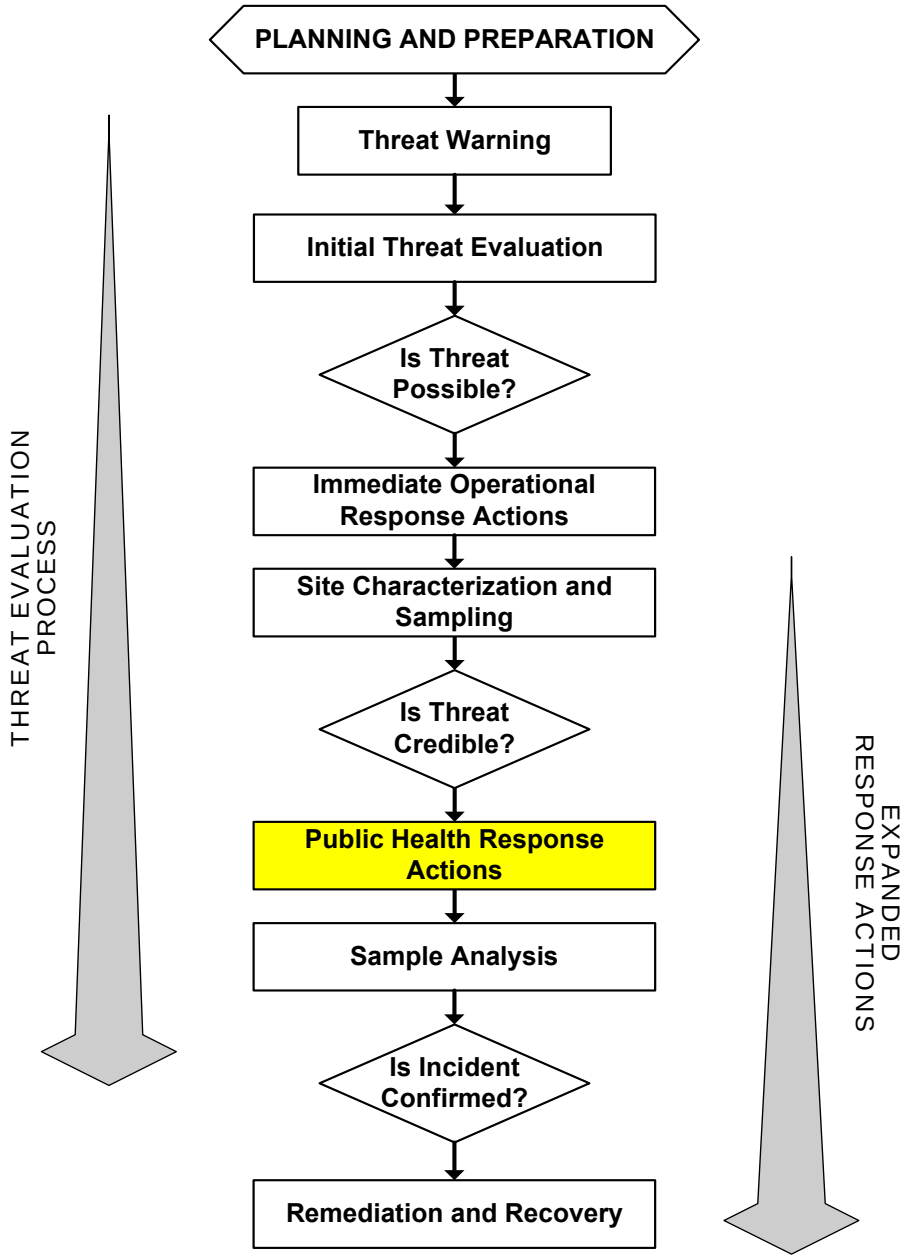
Interim Final - April 2004

Module 5: Public Health Response Guide

Response Protocol Toolbox:
Planning for and Responding to
Drinking Water Contamination Threats and Incidents

Module 5: Public Health Response Guide

Interim Final – April 2004



OTHER RESPONSE PROTOCOL TOOLBOX MODULES

Module 1: Water Utility Planning Guide *(December 2003)*
Module 1 provides a brief discussion of the nature of the contamination threat to the public water supply. The module also describes the planning activities that a utility may undertake to prepare for response to contamination threats and incidents.

Module 2: Contamination Threat Management Guide *(December 2003)*
Module 2 presents the overarching framework for management of contamination threats to the drinking water supply. The threat management process involves two parallel and interrelated activities: 1) evaluating the threat, and 2) making decisions regarding appropriate actions to take in response to the threat.

Module 3: Site Characterization and Sampling Guide *(December 2003)*
Module 3 describes the site characterization process in which information is gathered from the site of a suspected contamination incident at a drinking water system. Site characterization activities include the site investigation, field safety screening, rapid field testing of the water, and sample collection.

Module 4: Analytical Guide *(December 2003)*
Module 4 presents an approach to the analysis of samples collected from the site of a suspected contamination incident. The purpose of the Analytical Guide is **not** to provide a detailed protocol. Rather, it describes a framework for developing an approach for the analysis of water samples that may contain an unknown contaminant. The framework is flexible and will allow the approach to be crafted based on the requirements of the specific situation. The framework is also designed to promote the effective and defensible performance of laboratory analysis.

Module 5: Public Health Response Guide *(April 2004)*
Module 5 deals with the public health response measures that would potentially be used to minimize public exposure to potentially contaminated water. It discusses the important issue of who is responsible for making the decision to initiate public health response actions, and considers the role of the water utility in this decision process. Specifically, it examines the role of the utility during a public health response action, as well as the interaction among the utility, the drinking water primacy agency, the public health community, and other parties with a public health mission.

Module 6: Remediation and Recovery Guide *(April 2004)*
Module 6 describes the planning and implementation of remediation and recovery activities that would be necessary following a confirmed contamination incident. The remediation process involves a sequence of activities including: system characterization; selection of remedy options; provision of an alternate drinking water supply during remediation activities; and monitoring to demonstrate that the system has been remediated. Module 6 describes the types of organizations that would likely be involved in this stage of a response, and the utility's role during remediation and recovery.

ACKNOWLEDGEMENTS

This document was prepared by the United States Environmental Protection Agency, Office of Ground Water and Drinking Water, Water Security Division through a contract with SAIC. The EPA Work Assignment Manager was Brain Frazer, and the SAIC Work Assignment Manager was Mary Wolfe. The primary contributors to the document included:

- Steven C. Allgeier (US EPA, OGWDW)
- Mark J. Klingenstein (SAIC)
- Jennifer L. Larkin (SAIC)
- Carol A. Winston (SAIC)

Other contributors included Susan Dolgin, Grace Robiou, and Veronika Pesinova of the US EPA, OGWDW.

Additional support for this work was provided by a panel of peer reviewers, including: Cliff Bowen (California DHS), Keith Burkhart (ATSDR), Lisa Christ (US EPA, OGWDW), Steve Clark (US EPA, OGWDW), Steve Dennis (Alameda County Water District), Lauren DiSano (US EPA, ORD), Ron Hunsinger (EBMUD), Kim Fox (US EPA, ORD), Audrey Galizia (USEPA, ORD), David Hartman (Cincinnati Water Works), Vincent Hill (CDC), Craig D. Jackson (NYSDOH Bureau of Water Supply Protection), Dennis Juranek (CDC), Bart Koch (MWD So. Cal.), Janice Lee (Wisconsin DPH), Carrie Lewis (Milwaukee Water Works), Matthew Magnuson (USEPA, ORD), Maureen McClelland (US EPA, Region 1), Janet Pawlukiewicz (US EPA, OGWDW), Alan Roberson (AWWA), Eletha Brady-Roberts (USEPA, ORD), Stanley States (Pittsburgh Water and Sewer Authority), Gene Taylor (US EPA, Region 10), Gregory Welter (O'Brien & Gere Engineers), James Wheeler (US EPA, OWM), Caroline Wehling (US EPA, OGC), and Kelvin Yamada (California DHS).

TABLE OF CONTENTS

1 INTRODUCTION: OBJECTIVES AND ORGANIZATION OF THE MODULE 14

2 OVERVIEW OF PUBLIC HEALTH RESPONSE 16

2.1 PUBLIC HEALTH RESPONSE PLANNING 18
2.1.1 Integrating Public Health Response Planning into ERPs 18
2.1.2 Identification of Agencies Involved in Public Health Response 20
2.1.2 Development of Communications Strategy 23
2.1.3 Development of Operational and Public Health Response Actions 26

3 PUBLIC HEALTH CONSEQUENCES DUE TO WATER CONTAMINATION 28

3.1 CONTAMINANT PROPERTIES 28
3.2 ASSESSING THE SPREAD OF CONTAMINANT IN THE SYSTEM 32
3.2.1 Manual Assessment Methods 33
3.2.2 Water Distribution Models 35

4 OPERATIONAL RESPONSE OPTIONS 38

4.1 CONTAINMENT OF SUSPECT/CONTAMINATED WATER 38
4.2 NOVEL OPERATIONAL RESPONSES TO CONTAMINATION 42

5 PUBLIC NOTIFICATION STRATEGY 43

5.1 HOW TO DECIDE WHAT TYPE OF PUBLIC NOTIFICATION IS APPROPRIATE 43
5.2 TARGET AUDIENCE 46
5.3 CONTENT AND FORMAT OF THE PUBLIC NOTIFICATION 46
5.3.1 Content 47
5.3.2 Format 48
5.3.3 Notifications for Special Populations 49
5.3.4 Data Visualization and Interpretation Tools 50
5.4 METHODS TO DELIVER THE PUBLIC NOTIFICATION 50

6 SHORT-TERM ALTERNATE DOMESTIC WATER SUPPLY 53

6.1 ALTERNATE SUPPLY FOR CONSUMER USE 53
6.1.1 Who Provides the Alternate Water 54
6.1.2 Potential Household Sources of Emergency Water Supply 55
6.2 ALTERNATE SUPPLY FOR FIREFIGHTING NEEDS 57

7 RETURNING TO NORMAL OPERATION AND USE 59

8 REFERENCES AND RESOURCES 60

9 APPENDICES 62

9.1 CONTAMINANT CHARACTERIZATION AND TRANSPORT WORKSHEET 62
9.2 PUBLIC HEALTH RESPONSE ACTION WORKSHEET 68
9.3 EXAMPLE NOTIFICATIONS 72
9.3.1 Example Boil Water Notice 73
9.3.2 Example Do Not Drink Notice 74
9.3.3 Example Do Not Use Notice 75
9.3.4 Example Notice for an Unknown Contaminant 76
9.4 DESCRIPTION OF THE PIPELINENET DISTRIBUTION SYSTEM MODEL 77

LIST OF TABLES

TABLE 5-1. PUBLIC HEALTH RESPONSE - ENTITIES THAT SHOULD BE NOTIFIED 25
TABLE 5-2. OPTIONS FOR SHORT-TERM ALTERNATE SUPPLIES OF DRINKING WATER 27
TABLE 5-3. PROPERTIES APPLICABLE TO BOTH BIOLOGICAL AND CHEMICAL CONTAMINANTS 28
TABLE 5-4. PROPERTIES APPLICABLE TO CHEMICAL CONTAMINANTS.....29
TABLE 5-5. PROPERTIES APPLICABLE TO BIOLOGICAL CONTAMINANTS 31
TABLE 5-6. OPTIONS FOR SHORT-TERM ALTERNATE SUPPLIES OF DRINKING WATER 54
TABLE 5-7. ALTERNATE WATER SOURCES IN THE HOME 55
TABLE 5-8. PUBLIC GUIDANCE ON WATER PURIFICATION.....56

LIST OF FIGURES

FIGURE 5-1. RELATIONSHIPS AMONG COMPONENTS OF PUBLIC HEALTH RESPONSE 17
FIGURE 5-2. DECISION PROCESS FOR CONTAINMENT AS A PUBLIC HEALTH RESPONSE 39
FIGURE 5-3. COMPARISON OF CONTAMINANT SPREAD WITH AND WITHOUT VALVE CLOSURE.....41
FIGURE 5-4. EXAMPLE DECISION PROCESS FOR PUBLIC NOTIFICATION 44
FIGURE 5-5. OUTPUT OF SELECTION PROCESS SHOWING POTENTIAL MONITORING LOCATIONS. ..79
FIGURE 5-6. WATER QUALITY SIMULATION. 81
FIGURE 5-7. CONSEQUENCE ASSESSMENT TOOL. 82
FIGURE 5-8. ISOLATION TOOL INTERFACE. 83

DISCLAIMER

The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

DISCLAIMER

This module summarizes and contains references to specific sections of the Code of Federal Regulations (CFR) and to specific Statutes that codify the Nation's environmental laws (e.g., the Public Notification Rule). The summaries contained herein do not substitute for these requirements. Interested persons should become familiar with the actual federal regulations and Statutes themselves, or the corresponding regulation adopted by the primacy agency.

ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
CCR	Consumer Confidence Report
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
DHHS	Department of Health and Human Services
DHS	Department of Homeland Security
EMPACT	Environmental Monitoring for Public Access and Community Tracking
EMS	Emergency medical services
EPS	Extended period simulations
ERP	Emergency response plan
ESF	Emergency support function
ESRI	Environmental Systems Research Institute
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
GIS	Geographic information system
HSPD	Homeland Security Presidential Directive
ICS	Incident Command System
JIC	Joint information center
LRN	Laboratory Response Network
NACCHO	National Association of City and County Health Officials
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEDSS	National Electronic Disease Surveillance System
NIOSH	National Institute for Occupational Safety and Health
NRP	National Response Plan
OSWER	Office of Solid Waste and Emergency Response
PAO	Public Affairs Officer
PN	Public notification
PPE	Personal protective equipment
RAIS	Risk Assessment Information System
RR-MO	FEMA's Response and Recovery Directorate's Mobile Operations Division
RTECS	Registry of Toxic Effects of Chemical Substances
SDWA	Safe Drinking Water Act
UKWIR	United Kingdom Water Industry Research
USACE	United States Army Corps of Engineers
USAMRIID	United States Army Medical Research Institute of Infectious Diseases
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
WaterISAC	Water Information Sharing and Analysis Center
WCIT	Water contaminant information tool
WHO	World Health Organization
WUERM	Water Utility Emergency Response Managers

GLOSSARY

Definitions in this glossary are specific to the Response Protocol Toolbox but have been conformed to common usage as much as possible.

Agency – a division of government with a specific function, or a non-governmental organization (e.g., private contractor, business, etc.) that offers a particular kind of assistance. In the Incident Command System, agencies are defined as jurisdictional (having statutory responsibility for incident mitigation) or assisting and/or cooperating (providing resources and/or assistance).

'Confirmatory' Stage – the third stage of the *threat management* process from the point at which the threat is deemed 'credible', through the determination that a contamination incident either has or has not occurred.

'Confirmed' – in the context of the *threat evaluation* process, a water contamination incident is 'confirmed' if the information collected during the threat evaluation process provides definitive evidence that the water has been contaminated.

Consequence – the adverse outcome resulting from a drinking water contamination incident. In the context of the *threat management* process, the consequence considers both the number of individuals potentially affected as well as the severity of the health effect experienced upon exposure.

Consequence Management – DHS defines consequence management as measures to protect public health and safety, restore essential government services, and provide emergency relief to governments, businesses, and individuals affected by the consequences of terrorism.

Contaminant – any chemical, biological, or radiological substance that has an adverse effect on public health or the environment.

Contamination Site – the location where a contaminant is known or suspected to have been introduced. For example, a distribution system storage tank where a security breach has occurred may be designated as a suspected contamination site. The contamination site will likely be designated as an *investigation site* for the purpose of *site characterization*.

'Credible' – in the context of the *threat evaluation* process, a water contamination threat is 'credible' if information collected during the threat evaluation process corroborates information from the *threat warning*.

'Credible' Stage – the second stage of the *threat management* process from the point at which the threat is deemed 'possible', through the determination as to whether or not the threat is 'credible'.

Drinking Water Primacy Agency – the *agency* that has primary enforcement responsibility for national drinking water regulations, namely the Safe Drinking Water Act as amended. Drinking water primacy for a particular State or tribe may reside in one of a variety of agencies, such as health departments, environmental quality departments, etc. or may be US EPA. The drinking water primacy agency may also play the role of *technical assistance provider* to drinking water utilities.

Emergency Operations Center – a pre-designated facility established by an *agency* or jurisdiction to coordinate the overall agency or jurisdictional response to an emergency.

Emergency Response Plan – a document that describes the actions that a drinking water utility would take in response to various emergencies, disasters, and other unexpected incidents.

Field Safety Screening – screening performed to detect environmental hazards (i.e., in the air and on surfaces) that might pose a threat to the *site characterization* team. Monitoring for radioactivity as the team approaches the site is an example of field safety screening.

Immediate Operational Response – an action taken in response to a 'possible' contamination threat in an attempt to minimize the potential for exposure to the suspect water. Immediate operational response actions will generally have a negligible impact on consumers.

Impact – the consequence or effect on drinking water consumers, or the utility itself, that results from the implementation of response actions. An impact could also be considered as the cost of implementing a response action.

Incident – a confirmed occurrence that requires response actions to prevent or minimize loss of life or damage to property and/or natural resources. A drinking water contamination incident occurs when the presence of a harmful contaminant has been confirmed.

Incident Command System – a standardized on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Incident Commander – the individual responsible for the management of all incident operations.

Information Officer – the individual responsible for interfacing with the public and media or with other agencies requiring information directly from the incident. Under the Incident Command System, there is only **one** Information Officer per incident.

Investigation Site – the location where site characterization activities are performed. If a suspected *contamination site* has been identified, it will likely be designated as a primary investigation site. Additional or secondary investigation sites may also be identified due to the potential spread of a contaminant.

Joint Information Center – a center established to coordinate the Federal public information activities on-scene. It is the central point of contact for all news media at the scene of the incident. Public information officials from all participating Federal agencies should co-locate at the JIC. Public information officials from participating State and local agencies also may co-locate at the JIC.

Lead Agency – as defined in Homeland Security Presidential Directive-7 (HSPD-7), the Federal department or agency assigned lead responsibility to manage and coordinate a specific function — either crisis management or consequence management. Lead agencies are designated on the basis that they have the most authorities, resources, capabilities, or expertise relative to accomplishment of the specific function.

Mutual Aid Agreement – written agreement between agencies and/or jurisdictions in which they agree to assist one another upon request by furnishing personnel, equipment, or water.

'Possible' – in the context of the *threat evaluation* process, a water contamination threat is characterized as 'possible' if the circumstances of the *threat warning* appear to have provided an opportunity for contamination.

'Possible' Stage – the first stage of the *threat management* process from the point at which the *threat warning* is received through the determination as to whether or not the threat is 'possible'.

Public Health – the health and well being of an entire population or community. Public health is not limited to the health of individuals.

Public Health Response Plan – a document that describes public health response actions taken in response to various emergencies, disasters, and other unexpected incidents. The Public Health Response Plan is typically developed by the State Health Department.

Public Notification – under the Safe Drinking Water Act, public water systems are required to notify their customers when they violate US EPA or State drinking water standards (including monitoring requirements) or otherwise provide drinking water that may pose a risk to consumers' health.

Rapid Field Testing – analysis of water during *site characterization* using rapid field water testing technology in an attempt to tentatively identify contaminants or unusual water quality.

Response Decisions – part of the *threat management* process in which decisions are made regarding appropriate response actions that consider 1) the conclusions of the *threat evaluation*, 2) the consequences of the suspected contamination incident, and 3) the impacts of the response actions on drinking water customers and the utility.

Response Guidelines – a manual designed to be used **during** the response to a water contamination threat. Response Guidelines should be easy to use and contain forms, flow charts, and simple instructions to support staff in the field or decision officials in the *Emergency Operations Center* during management of a crisis.

"Reverse 911" Messaging – a communications product that establishes a virtual calling network. This system enables public safety agencies to telephone community residents with recorded messages informing them of emergencies, hazards, major road closures, or other important matters relevant to public health and public safety. The system is built on a database of local resident and business phone numbers.

Site Characterization – the process of collecting information from an *investigation site* in order to support the evaluation of a drinking water contamination threat. Site characterization activities include the site investigation, *field safety screening*, *rapid field testing* of the water, and sample collection. Site characterization is discussed in Module 3.

System Characterization – a detailed assessment of the nature and extent of contamination in a drinking *water system* for the purpose of planning remediation of the contaminated *water system*. The system characterization process is modeled, in part, on the concept of a *remedial investigation* under EPA's Superfund program and, similarly, would be done with the *feasibility study*.

Technical Assistance Provider – any organization or individual that provides assistance to drinking water utilities in meeting their mission to provide an adequate and safe supply of water to their customers. The *drinking water primacy agency* may serve as a technical assistance provider.

Terrorist Incident – the FBI defines a terrorist incident as a violent act, or an act dangerous to human life, in violation of the criminal laws of the United States or of any State, to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives.

Threat – an indication that a harmful *incident*, such as contamination of the drinking water supply, may have occurred. The threat may be direct, such as a verbal or written threat, or circumstantial, such as a security breach or unusual water quality.

Threat Evaluation – part of the *threat management* process in which all available and relevant information about the threat is evaluated to determine if the threat is 'possible' or 'credible', or if a contamination *incident* has been 'confirmed'. This is an iterative process in which the threat evaluation is revised as additional information becomes available. The conclusions from the threat evaluation are considered when making *response decisions*.

Threat Management – the process of evaluating a contamination threat and making decisions about appropriate response actions. The threat management process includes the parallel activities of the *threat evaluation* and making *response decisions*. The threat management process is considered in three stages: 'possible', 'credible', and 'confirmatory'. The severity of the threat and the magnitude of the response decisions escalate as a threat progresses through these stages.

Water Contamination Incident – a situation in which a contaminant has been successfully introduced into the system. A water contamination incident may or may not be preceded by a water contamination threat.

Water Contamination Threat – a situation in which the introduction of a contaminant into the water system is threatened, claimed, or suggested by evidence. Compare *water contamination threat* with *water contamination incident.* Note that threatening a water system may be a crime under the Safe Drinking Water Act as amended by the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

Water Utility Emergency Response Manager (WUERM) – the individual(s) within the drinking water utility management structure that has the responsibility and authority for managing certain aspects of the utility=s response to an emergency (e.g., a contamination threat) particularly during the initial stages of the response. The responsibilities and authority of the WUERM are defined by utility management and will likely vary based on the circumstances of a specific utility.

1 Introduction: Objectives and Organization of the Module

The primary intended users of this module include water utility staff and agencies, *drinking water primacy agencies*, and *technical assistance providers* that will assist water utilities during the response to a *water contamination threat* or *incident*. In addition, public health *agencies* (e.g., US Environmental Protection Agency, State and local health departments, Centers for Disease Control and Prevention) are encouraged to read this module because they will typically be involved in choosing and implementing the public health response actions taken during a water contamination threat. The objective of Module 5 is to help the user understand the issues and activities involved in public health response to a contamination incident or threat, including:

- Identification of the organizations and officials responsible for making and implementing public health *response decisions* for drinking water.
- Understanding the role of the drinking water utility during public health response to a water contamination threat.
- Evaluation of the public health consequences due to water contamination, and identification of resources and techniques to aid in consequence evaluation.
- Evaluation of response options to limit exposure to the public, by containing the suspect water and/or notifying the public to limit their use of the water.
- Development of communication procedures and structures both within the responding organizations and also for communication with the public and the media.
- Identification of potential short-term alternate water supplies.

This module is organized into eight sections as described below. Water utility and public health officials are encouraged to review this module in its entirety, as well as the other modules in the "Response Protocol Toolbox," to obtain a comprehensive understanding of public health response for water contamination threats and incidents.

Section 1: Introduction: describes the overall organization and objectives of this module.

Section 2: Overview of Public Health Response: describes the organizations that may be involved in public health response decisions, response options, *impacts* of particular response actions, and communications.

Section 3: Public Health Consequences due to Water Contamination: includes general procedures for evaluating contaminant characteristics such as acute and chronic effects of exposure, exposure routes, and stability of the contaminant in water, and methods of estimating the spread of contaminated water.

Section 4: Operational Response Options: describes containment options and other novel operational responses.

Section 5: Public Notification Strategy: discusses public notification as a means of reducing or mitigating exposure and avoiding panic.

Section 6: Short-term Alternate Domestic Water Supply: discusses issues to be considered in planning for an alternate water supply to meet the needs of domestic consumption and sanitation, firefighting activities, and customers with special requirements. (This section will consider the need for an alternate water supply over a short duration. Long-term alternate water supply needs will be addressed in Module 6.)

Section 7: Returning to Normal Operations and Use: describes the actions to be taken and presents examples of returning to normal operations.

Section 8: References and Resources: includes literature citations, sources of internet information, and other publications of relevance to public health response.

Section 9: Appendices: includes forms and tools that support this module and that may aid in preparing for public health response to a contamination threat.

2 Overview of Public Health Response

In the context of this module, public health response can be defined as the actions taken to mitigate consequences resulting from threats or incidents involving biological, chemical, or radiological contaminants. Public health response is one component of the *threat management* process, which is described in detail in Module 2. Figure 5-1 provides an overview of the public health response process, which is considered in the following five major components:

1. Conduct planning – During the planning phase, the roles and responsibilities of the agencies involved in public health response are identified; the communication strategy is developed; and the feasibility of potential operational response actions is evaluated. A water utility may choose to address its role during a public health response as part of the development or revision of its emergency response plan (ERP). As part of planning, identified gaps in operating procedures, technical capabilities, and communication should be addressed. As with all response plans, regular exercising of the plan is critical to effective implementation. The planning component is discussed in Section 2.1 of this module.
2. Determine public health consequences due to water contamination – This is the process of assessing the properties and health effects of contaminants, as well as the potential spread of the contaminated water, which will support appropriate public health response decisions. However, the detailed information necessary to assess potential health consequences will be unknown or poorly characterized in the time frame in which public health decisions need to be made in many cases. The utility and public health agencies should be prepared to respond given these uncertainties, as discussed in Section 3 of this module.
3. Implement operational responses – Certain operational responses identified during the planning process may be implemented in response to a *'possible'* or *'credible'* contamination threat if they are deemed feasible and effective. These operational response actions are generally limited to containment of suspect water in a distribution system, but other novel operational responses may be considered, as discussed in Section 4 of this module.
4. Implement public notification strategy – The public notification strategy will aid in the development and distribution of appropriate notifications and instruction to the public. These notifications will be a key component of an effective response to a 'credible' threat or *'confirmed'* incident. Section 5 provides guidance regarding the development of appropriate and effective public notification.
5. Implement alternate water supply - If restrictions are placed on water consumption or use due to a public health response action, it may be necessary to provide an alternate supply of domestic water. Section 6 discusses various options for short-term alternate drinking water supplies and their implementation by the appropriate organization.

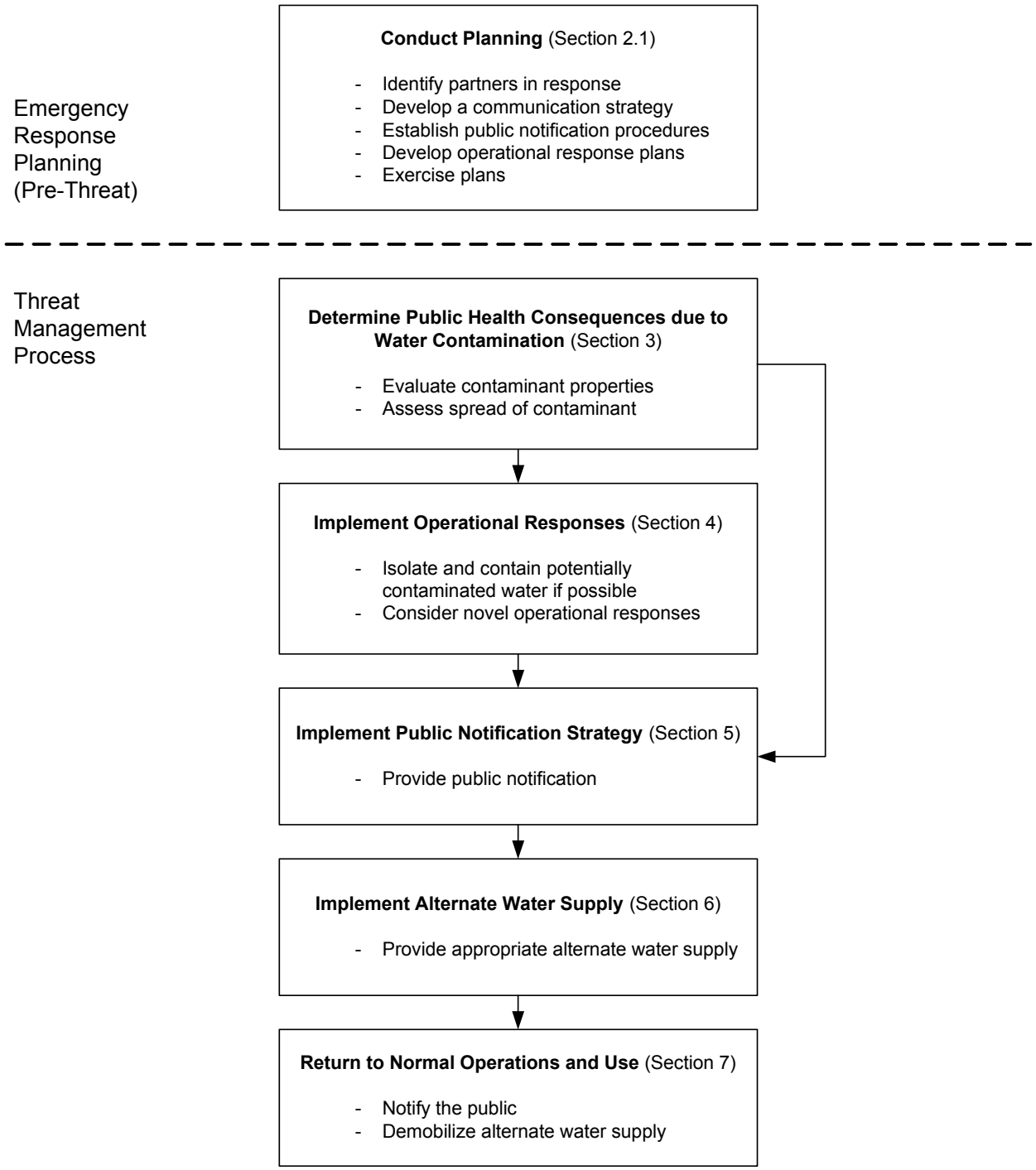


Figure 5-1. Relationships among Components of Public Health Response

While Figure 5-1 is shown as a sequential process, the implementation steps are not necessarily implemented sequentially, but rather may be implemented individually or in combination at any point throughout the threat management process. For example, it is highly possible that the water utility could be evaluating the contaminant's properties, implementing containment, and providing public notification simultaneously during one or more stages of the threat management

process. The consideration of each public health response action at the 'possible', 'credible', and 'confirmatory' stages of the threat management process is described in detail in Sections 3.1.8, 4.2.3, and 5.2 of Module 2, respectively.

2.1 Public Health Response Planning

This section describes four key components of public health response planning: integrating public health response planning into ERPs, identifying agencies involved in public health response, developing a communications strategy, and developing operational and public health response actions. These components are described in Sections 2.1.1, 2.1.2, 2.1.3 and 2.1.4, respectively.

In addition to these four key components, training is critical to ensuring smooth implementation of public health response. Training should be conducted for all parties with responsibilities under the Public Health Response Plan to ensure that all parties understand their role and can implement the plan properly. The utility also should conduct training on implementation of its ERP, including public communication and short-term alternate water supplies. Additionally, integrated public health response should be tested as part of a table-top or actual field exercise involving all parties with a role, such as public health agencies, the medical community, the utility, laboratories, and others. The National Association of City and County Health Officials (NACCHO) developed a table-top exercise template tool that parties may use to exercise their plans.

2.1.1 Integrating Public Health Response Planning into ERPs

Public health response planning should be integrated into planning at both the State and local levels. Before initiating public health response planning, a water utility should identify and evaluate any existing emergency response or public health response plans at the State or local level. Examples of such plans are described below.

State ERPs - States typically have ERPs that are wide-ranging and designed to address the range of emergencies the State may face. Among other objectives, these plans may address the protection of critical infrastructure, such as water, approaches to public health protection (described more fully in the State's Public Health Response Plan), and communications strategies at the State level. The State drinking water primacy agency may also have plans in place to address emergencies.

State or Local Health Department Public Health Response Plans - The State or local health department typically develops a Public Health Response Plan, which covers responses to a variety of public health emergencies, potentially including *water contamination incidents*. Such a plan may cover public health surveillance and epidemiological investigations conducted by the medical community, laboratory diagnosis, laboratory capacity planning, medical management, reconstruction of the patients' recent whereabouts to determine potential sources of exposure, and *consequence management*. To assist in the development of a Public Health Response Plan, the Centers for Disease Control and Prevention (CDC) published a planning guidance document entitled "The Public Health Response to Biological and Chemical Terrorism: Interim Planning Guidance for State Public Health Officials" (CDC, 2001a).

City or Regional ERPs - Cities or Regional governmental agencies often develop ERPs that establish a plan of action and organizational structure to efficiently respond to a variety of emergencies such as fires, floods, tornadoes, terrorism, chemical and biological weapons threats, workplace violence, major utility disruptions, etc. The plan may delineate the roles and responsibilities of each agency involved (municipal, State, Federal, and the private sector) in emergency response; define what constitutes and who declares an emergency; provide guidelines for implementation of the ERP components; and address communication procedures (e.g., creating a list of key public- and private-sector personnel who would respond to an emergency).

Utility ERPs - Finally, local drinking water utilities have ERPs that consider vulnerabilities identified during a vulnerability assessment and outline response plans for a variety of emergencies. The utility's ERP should identify Federal, State, and local agencies that need to be involved in response actions and address the roles and responsibilities of the utility and these agencies during public health response. These include a public notification strategy in the event of loss of potable water due to any cause, including contamination, and a plan for obtaining alternate water supplies should they be needed. The ERP should include procedures for rapidly initiating strategies to contain water suspected of being contaminated. To assist in the development of utility ERPs, US EPA published the following two documents: "Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002" (US EPA, 2003) and "Small and Medium Water System Emergency Response Plan Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002" (US EPA, 2004a).

Local and State health departments and utilities should work together to fine-tune their public health response plans for water contamination incidents. The utility should understand how the public health response plans of local and State health departments would address a water contamination incident and should integrate appropriate portions of these plans into the utility ERP. In some cases, the local and State health department's plan may need to be modified to address a water contamination incident. The utilities and public health departments should establish specific agreements on standardized communications protocols, triggers for initiating notifications between the health department and water utility, and analytical support from public health labs.

In addition, there may be potential challenges in sharing data between the public health agency and the utility (e.g., the public health agency may not be able to share addresses based on patient privacy constraints). The utility and public health agency should review any requirements for special clearances necessary to share public health and utility data as part of planning for a public health response.

The level at which public health response to a water contamination threat or incident starts and which ERP takes precedence will depend on the nature of the incident. Some of the factors that may determine which ERP takes precedence include who discovers the incident, whether Federal agencies are involved, and whether the public is already experiencing illnesses. Furthermore, the lead agency and the role of supporting agenicies may change during an incident, as discussed in

Module 1. To facilitate these transitions, utilities and other agencies should incorporate the Incident Command System (ICS) in their ERPs, which is discussed in Module 1, Section 4.4.

2.1.2 Identification of Agencies Involved in Public Health Response

In preparing a Public Health Response Plan, the State health department will most likely identify the agencies (at the Federal, State, and local levels) to be involved in response during any type of public health emergency, which would include water contamination incidents. Examples include local (often county or city-level) public health agencies, medical centers and hospitals, regional poison control centers, State health departments and laboratories, and Federal agencies such as the Department of Health and Human Services (DHHS) [including CDC and the Agency for Toxic Substances and Disease Registry (ATSDR)] and the United States Environmental Protection Agency (US EPA). The roles and responsibilities of each of the identified agencies involved in public health response should be defined in the Public Health Response Plan.

Significant roles and areas of responsibility for selected agencies and groups in support of public health response are described below. In addition, the roles and responsibilities of the water utility, which plays an important role in public health response to water contamination incidents, are described in detail at the end of this section. These agencies and groups are subject to various regulatory requirements, so their roles and responsibilities are subject to applicable regulations and hence may be dependent on the nature of the contamination threat or incident. The roles and responsibilities for other Federal agencies are discussed throughout the remainder of this module where appropriate (also in Module 1, Appendix 6.2 and Module 6, Section 2.2).

Water Utility – The water utility will possess the most detailed first-hand knowledge and technical expertise regarding the configuration and operation of the water source, storage, treatment, and distribution systems. Accordingly, water utility personnel will support immediate operational responses (e.g., evaluation and implementation of containment options). The water utility personnel will also be experts in interpreting and explaining their operational and water quality data, and can provide an historic perspective to the interpretation of this data. In addition, the water utility will support, or potentially be the lead agency for public notification, depending on arrangements made with the State/local health department or drinking water primacy agency. The water utility may also provide accurate and up-to-date information on the water system to the designated information officer or media point of contact. It is especially important that during public health response planning, local health departments and utilities hold joint discussions and develop an integrated response plan for water-related events that clearly defines each organization's respective roles and responsibilities to ensure that their plans are consistent with existing State and local emergency response plans. The utility should participate in drills designed to exercise communication networks, with the understanding that the utility may not be the lead agency for public notification when dealing with intentional contamination.

Drinking water primacy agency – The drinking water primacy agency is the agency that has primary enforcement responsibility for national drinking water regulations, namely, the Safe Drinking Water Act as amended. The drinking water primacy agency is typically the State public health department or the State environmental agency; however, US EPA is the drinking water primacy agency for Wyoming, the District of Columbia, and most of Indian country. The drinking water primacy agency will provide guidance and oversight of public notifications. The drinking water primacy agency should work with the State to ensure that the State's ERP

addresses water emergencies and with the water utility to ensure that its ERP is consistent with the State's ERP. Additional roles and responsibilities of the State public health department and US EPA in support of public health response are described below.

State public health department – The State public health department is responsible for developing a Public Health Response Plan that includes an effective communications strategy and identifies specific actions to take in response to all types of public health emergencies, including terrorist incidents. The health department may also coordinate the investigation and control of disease, including coordinating the allocation of medications essential to the public and implementing appropriate public health response actions (e.g., issue health advisories and protective action guides to the public). The State public health department also typically has a clinical laboratory that is part of the LRN and which may provide analytical support, particularly for biological contaminants, in the case of a suspected contamination incident. The State health department also provides support to local emergency operations and serves as liaison to Federal and emergency health and medical programs and services.

Local public health department – The local public health departments may assist in diagnosing and investigating disease outbreaks and may have their own disease surveillance system in place. They may coordinate the care to be provided by local health care entities and provide mass prophylaxis to prevent epidemics. Local public health departments may have authority and responsibility to issue public notification to protect public health. In addition, the local public health department may concur with the water utility regarding public notification required under the Safe Drinking Water Act (SDWA).

Hospital staff, clinics, physicians, and poison control centers – In accordance with individual State laws, health care personnel report to the appropriate designated agency information on respiratory infections, skin rashes, diarrhea, and other syndromes that may provide an early warning of an outbreak of diseases such as anthrax, plague, and smallpox, as well as the intentional release of more common infectious agents. The ongoing reporting, compilation, and analysis of this data can lead to the early detection of *terrorist incidents* as well as other potential public health emergencies. Health care personnel are also responsible for proper care and treatment of the impacted public and containment of infectious diseases to the maximum degree possible. Regional poison control centers have expertise in the diagnosis and management of poisoning, including those involving hazardous substances. In addition, they are actively involved in surveillance, including collaboration with the CDC and ATSDR. The closest poison control center can be reached by the national toll free number, 1-800-222-1222.

State office of emergency services – Most State offices of emergency services coordinate overall State agency response to major disasters in support of local government. The office is usually responsible for assuring the State's readiness to respond to, and recover from, natural, man-made, or war-caused emergencies and assisting local governments with emergency response and recovery efforts. It is important for water utilities and public health agencies to involve their State office of emergency services in the planning process to investigate the types of resources this office can provide in a crisis.

Local office of emergency services – Most city or county offices of emergency services are mandated to coordinate disaster activities, before, during, and following catastrophic emergencies impacting the citizens of their particular jurisdiction. Local emergency service

offices usually provide planning, training, and coordination to county or city departments and other agencies within their jurisdiction. In most States, these local offices can provide a link to State and Federal resources during a disaster.

US Environmental Protection Agency (US EPA) – US EPA will typically activate technical capabilities to support the Federal response to terrorist incidents. US EPA may coordinate with individual agencies identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to use the structure, relationships and capabilities of the National Response System as described in the NCP [40 Code of Federal Regulations (CFR) Part 300 subpart B] to support the response operations. US EPA will also provide resources to help the water utility assess the public health consequences due to a particular water contaminant and the appropriate operational response actions to take.

Centers for Disease Control and Prevention (CDC) – An operating division of DHHS, CDC develops resources to assist hospital staff, clinics, and physicians in diagnosing diseases related to terrorism, reporting incidences of disease, and controlling the spread of infection. Working with States and other partners, CDC provides a system of health surveillance to monitor disease and minimize the spread of outbreaks, implement disease prevention strategies, and maintain national health statistics. CDC provides expertise for investigating unusual public health episodes, environmental contamination, and unexplained illnesses. In 1999, CDC established the Laboratory Response Network (LRN), which is a national network of approximately 120 clinical laboratories that can respond to biological and chemical terrorism. LRN's resources may be activated when the FBI designates that there is a credible threat to water.

Agency for Toxic Substances and Disease Registry (ATSDR) - An operating division of DHHS, ATSDR performs specific functions concerning the public health effects of hazardous substances in the environment. Some of these functions include health surveillance and registries, response to emergency releases of hazardous substances, applied research in support of public health assessments, and information development and dissemination.

Federal Emergency Management Agency (FEMA) – FEMA, which is part of the Department of Homeland Security (DHS), is the lead Federal agency for supporting State and local response to the consequences of public health emergencies, including natural disasters and terrorist attacks. In response to requests from State or local agencies, FEMA provides support through the Response and Recovery Directorate's Mobile Operations Division, which can provide mobile telecommunications, operational support, life support, and power generation (FEMA, 2003d). FEMA may also train emergency personnel in preparation for emergency situations (FEMA, 2003a).

US Army Corps of Engineers (USACE) – Under National Response Plan (NRP) Emergency Support Function (ESF) #3, Infrastructure Annex, USACE, along with FEMA, serves as one of the primary agencies responsible, in part, for emergency restoration of critical public facilities (e.g., temporary restoration of water supplies and emergency contracting to support public health and safety).

Coordination among public health response agencies at all levels is critical to the successful implementation of public health response actions. The mechanisms for this coordination may be via phone, pagers, or any other means of rapid and reliable communication. Another valuable

tool for rapid information exchange is the Water Information Sharing and Analysis Center (WaterISAC). WaterISAC (www.waterisac.org) is a highly secure, Web-based information service available only to subscribers. It provides drinking water and wastewater utility managers with fast access to sensitive information about physical, contamination, and cyber threats. Established by the Association of Metropolitan Water Agencies, with support from US EPA, WaterISAC gathers, analyzes, and disseminates information on threats and incidents that is specific to the water sector. It serves as an important link between the water sector and Federal environmental, homeland security, law enforcement, intelligence, and public health agencies. In addition to providing a forum for sensitive water security discussions, WaterISAC provides information resources for improvements to water system security and emergency response plans.

2.1.2 Development of Communications Strategy

Reliable and rapid communications are crucial to ensure a prompt and coordinated public health response to a water contamination threat or incident. The first step for a successful response is information sharing and communication among water utilities, public health response agencies, emergency response agencies, and any other agencies with identified roles during a public health response. Ongoing communication of accurate and up-to-date information can facilitate public health response by the responsible agencies, help to minimize public health consequences, and aid in calming public fears.

Especially important is communication with public health agencies. Two-way communication between water utilities and public health agencies is critical and should be routinely tested in advance of a water contamination threat or incident. The *Incident Commander* (see Module 1, Section 4.4) of the investigation, who may or may not be from the utility, should report a '*credible*' *contamination threat* to public health agencies so physicians, hospital staff, and clinical laboratories can be alerted regarding potential signs and symptoms that should be reported to the public health department. In some cases, the contamination threat may be identified by public health agencies, and arrangements should be made for public health agencies to communicate with water utilities regarding unusual symptoms that may have a connection to drinking water.

The drinking water utility and public health officials should develop criteria regarding when these notifications should occur and identify the key contacts within each agency to ensure that effective communications occur as a potential water-related public health incident unfolds. Public health agencies should implement public health surveillance procedures to determine if an increase in the occurrence of unusual symptoms, or an increase in sales of over-the-counter pharmaceutical products, warrants an investigation. The public health agencies' notification procedures should include notification to the drinking water utility if it is determined that the drinking water is a potential cause of the increased death/disease. Coordination of notification procedures between the Public Health Response Plan and the utility's ERP will be critical to seamless notification protocols. Where available, electronic means of information exchange/communication can greatly enhance communications and the speed of response. One such example is the National Electronic Disease Surveillance System (NEDSS) being developed by CDC for automated, timely electronic capture of data from the healthcare system.

Some critical features of effective communications are as follows:

- A comprehensive communications and public notification strategy addresses the "why, who, when, what, and how" of relaying information to agencies involved in public health response, as well as to the media and public when necessary. It should identify the information to be communicated, target audience, potential dissemination vehicles, resources required, and feedback mechanisms.
- The strategy should include a list of entities to be contacted and a notification roster that contains the appropriate contact names, titles, addresses, and all applicable landline, cellular phone, and pager numbers. The list should also identify the secondary contact if the primary contact in an organization cannot be reached in a reasonable amount of time. This list should be maintained and updated on a periodic basis. In addition, the communications protocol should define the reasonable amount of time and effort that should be expended before emergency response actions are taken without consulting the organizations that could not be reached. Whenever practical, the communications list should be standardized in format among agencies to allow ease and consistency in updating.
- In extreme emergencies (e.g., the terrorist incident involves more than contamination of the water system), it may not be possible to use normal channels of communication such as phones. Provisions should be made for an efficient and reliable form of backup communication to be available during emergency conditions when the use of normal facilities may be denied by the crisis. The utility, public health departments, and local or State emergency operations center may have already established backup forms of emergency communication.
- Communications protocols should be endorsed by all involved agencies, tested prior to finalization, and exercised periodically.

As presented in Module 1, the Incident Commander will decide on the appropriate communication to be implemented. The water utility should have its own strategy in the event that (1) they are responsible for incident command (potentially during the 'possible' and 'credible' stages of the threat management process) or (2) they are delegated responsibility for communication by the Incident Commander.

Table 5-1 consists of a list of potential entities to be notified as part of public health response, as well as the purpose of the notification for each entity notified. Each utility should identify in its ERP the appropriate entities to be notified. It is important to note that under 40 CFR Part 141, Subpart Q [the Federal Public Notification (PN) Rule], utilities must provide public notice to persons served by the water system in situations with significant potential to have serious adverse effects on human health as a result of short-term exposure. Such a situation requires a Tier 1 notice under the Federal Rule. Persons served by the water system include renters and transient populations in addition to billed customers.

The utility must also provide a copy of the public notice to the primacy agency. In addition, utilities that sell or otherwise provide drinking water to other public systems (i.e., consecutive systems) are required to give notice to the owner or operator of the system; the consecutive system is responsible for providing notice to the persons it serves. The PN Rule is described more fully in Section 5.

Table 5-1. Public Health Response - Entities That Should Be Notified

Entity		Purpose of the Notification
Public Health Agencies	State/local health and/or environmental department	To work with these officials in making the decision on the distribution of "boil water," "do not drink," or "do not use" notices. These officials may be involved with public health decisions related to the proper use of the water supply, status of the water distribution system, selection of a short-term alternate water supply, and communicating the necessary public health information.
	Other associated system authorities (wastewater, water)	
	Poison Control Centers	
Emergency Responders	Emergency Medical Services (EMS)	To notify the organization of the need for assistance with the distribution of an alternate water supply (e.g., bottled water) and whether or not the contamination impacts the availability of water for firefighting. Also, these agencies should be provided with all information related to public health including: information on water notices, alternate water supplies, critical care facilities, and public health notifications.
	Fire Department	
	State and/or Local Office of Emergency Services	
Law	Federal, State, and local law enforcement	Local law enforcement should be notified immediately if a malevolent act is suspected. Law enforcement agencies should also be notified of the need for assistance with getting important information out to the public and the distribution of water from the short-term alternate water supply (i.e., distribution of bottled water, etc.). Law enforcement agencies should also be contacted because the public may be contacting them through 911 regarding the incident.
Consecutive Systems (i.e., public water systems that receive water from the water utility where the water contamination threat or incident occurred)		To provide information related to restrictions on the use of the drinking water supply, as well as instructions on obtaining alternate sources of drinking water, through the duration of the incident. Also, information should be provided on the status of the water supply, the potential problem, and what is being done to manage the incident.
Customers/Public		To provide information related to restrictions on the use of the drinking water supply, as well as instructions on obtaining alternate sources of drinking water, through the duration of the incident. Also, information may be provided on the status of the water supply, the potential problem, and what is being done to manage the incident. Section 5 provides more detailed guidance regarding public notification.
Customers with special needs	Critical care facilities (e.g., hospitals, clinics, nursing homes, dialysis centers)	These facilities should be some of the first to be notified. Information should be provided regarding the proper use of the water supply for public health purposes as well as the identity of the contaminant so these facilities can identify the symptoms of exposure as well as potential medical treatment. They may be given information on how water will be provided or how they need to obtain short-term alternate water supplies. Critical care facilities may also need to be notified of any changes in the type of chemical disinfection being used or the concentration of these chemicals in the water as this may affect some of their medical procedures.

Table 5-1. Public Health Response - Entities That Should Be Notified

Entity		Purpose of the Notification
	Schools	To provide information regarding restrictions on water use, alternate water supplies, and other public health information.
	Day Care Facilities	To provide information regarding restrictions on water use, alternate water supplies, and other public health information.
	Businesses (e.g., food and beverage manufacturers, commercial ice manufacturers, restaurants, agricultural operations, power generation facilities, any other businesses identified by the utility)	To provide information regarding restrictions on water use, alternate water supplies, and other public health information. These customers may also need information regarding whether heating or superheating the water may pose a hazard.
Other	Elected officials	To provide all information related to public health, including: the status of the *threat evaluation*, information on "boil water," "do not drink," or "do not use" notices, alternate water supplies, customers with special needs, and public health notifications.

2.1.3 Development of Operational and Public Health Response Actions

Module 2 presented a threat management process under which responses occur during the 'possible', 'credible', and 'confirmatory' stages. Public health response decisions, which may include containment of the suspect water and/or public notification regarding restrictions on water use, may need to be considered at each stage as a means of minimizing and/or preventing exposure to the suspect water. However, it is also necessary to consider the potential impacts of response actions on the public (e.g., the lack of a supply of water for drinking and sanitation). In many cases, the responsibility will fall on the water utility to determine the proper approach and methods to address water supply related impacts of various response actions.

Potential operational and public health response actions should be defined during the planning process. The plan should identify the agency or organization that is responsible for carrying out the action(s) as well as the circumstances under which the actions are to be taken (the "Threat Management Matrices" presented in Module 2 may be useful for this purpose). Operational responses to a 'possible' water contamination threat include isolating and containing the affected portion of the system and other novel operational responses. A detailed discussion of implementing operational responses can be found in Section 4 of this module.

Potential restrictions on water use that might be achieved through public notification include issuing a "boil water" notice, "do not drink" notice (no consumption), and "do not use" notice. A detailed discussion of implementing public notification can be found in Section 5 of this module.

An extremely important element of public health response is the identification of options and plans for a short-term alternate supply of drinking water if the public is notified not to drink or use the water. These options should be identified in the drinking water utility's ERP. Table 5-2

provides a list of potential options for short-term supplies. A detailed discussion of potential alternate water supplies can be found in Section 6 of this module.

Table 5-2. Options for Short-term Alternate Supplies of Drinking Water

Type	Source
Bottled water	Local government agencies
	Local retailers
Bulk water	Certified water haulers
	Military assets (i.e., National Guard)
	Neighboring water utilities
Utility treated	Uncontaminated source water treated by the utility
	Uncontaminated water stored in the distribution system

3 Public Health Consequences due to Water Contamination

Potential consequences of a contamination threat or incident should be considered to the extent possible when making public health response decisions. Two factors that influence the potential consequences include the contaminant properties and the spread of a contaminant through the water system. Once the contaminant has been identified, the water utility, working with other public health or law enforcement agencies, as appropriate, may need to access information on the public health consequences of that contaminant. The information, data, and methods needed to assess public health consequences of contaminants are presented in this section. In addition, this section examines various methods to assess the spread of a contaminant.

3.1 Contaminant Properties

Within this section, Tables 5-3, 5-4, and 5-5 contain an overview of properties important in evaluating the threat that a contaminant poses to public health, as well as a brief discussion of their relevancy in determining public health consequences. These properties should be considered collectively in determining the public health consequences of a particular contaminant. Sources that provide this type of information for specific contaminants are presented following these tables.

Table 5-3. Properties Applicable to both Biological and Chemical Contaminants

Property	Discussion
Acute Health Effects	Acute health effects occur immediately (i.e., within minutes to days) following short-term exposure (i.e., up to 30 days) to certain contaminants such as pathogens or chemicals that may be in drinking water and depend on the route of exposure. For example, the acute health effects following ingestion of ethylene glycol can lead to myocardial failure, renal failure, metabolic acidosis, tachycardia, upper gastrointestinal bleeding, tremors, agitation, ataxia, stupor, seizure, loss of consciousness, coma, and death (CDC, 2004). Since the acute health effects of many biological contaminants are flu-like, many health care providers may not make the connection between increases in flu-like symptoms in the community and a potential water contamination incident.
Chronic Health Effects	Chronic health effects can result from short-term exposure or prolonged exposure, presumably in low doses, to a contaminant. Contaminants causing long-term health effects are mostly chemical contaminants and include, among others, byproducts of solvents used by commercial and industrial facilities, disinfectants, pesticides, and metals such as lead and mercury. For example, chronic ingestion of small amounts of cyanide may lead to weakness of the fingers and toes, difficulty walking, dimness of vision, deafness, and decreased thyroid gland production (ATSDR, 1997a). Cyanide is regulated at 0.2 mg/L on the basis of these chronic health effects. Although less common, chronic effects can also result from exposure to biological agents. For example, chronic arthritis can result from acute exposure to Salmonella bacteria if Reiter's syndrome develops. Chronic health effects from prolonged exposure may determine the remedial goal for a contaminated water system, particularly if the contaminant is persistent in the system. Drinking water regulations prescribe maximum concentrations of several contaminants on the basis of chronic effects.

Table 5-3. Properties Applicable to both Biological and Chemical Contaminants

Property	Discussion
Taste/Odor/ Color	Although many contaminants will not be easily detectable via the five senses, those that produce a noticeable taste, odor, or color in water may pose less of a public health threat. These properties may alert consumers that the water may be unsafe, thus minimizing the use of contaminated water. For example, if a contaminant caused the water to have a strong, unpleasant odor (e.g., rotten eggs), it seems likely that many individuals would be deterred from consuming a sufficient quantity to cause serious health effects. However, these properties should not be relied on to eliminate exposure because some subpopulations (e.g., blind, elderly) may not be able to detect these changes. In addition, contaminants that adversely impact the aesthetic qualities of water, even if they have low health impacts, still present a problem because the public may refuse to use the water until the system is remediated.
Aerosolization	Aerosolization is the process of making particles of solid or liquid matter such that they can remain suspended in air for a few minutes to many months. The particle size and weight of contaminants will determine whether aerosolization is a concern and should be considered during the assessment of potential public health consequences. Specifically, chemical and biological contaminants likely to become suspended in air are more likely to pose a threat to public health through inhalation pathways (e.g., while showering).

Table 5-4. Properties Applicable to Chemical Contaminants

Property	Discussion
Toxicity Values (e.g., LD_{50}, LC_{50}, TD_{Lo}, TC_{Lo})	Toxicity values can be used to estimate the contaminant concentrations at which acute health effects will be realized in large portions of the population. Some examples of toxicity values include the lethal dose for 50 percent of the population (LD_{50}); lethal concentration for 50 percent of the population (LC_{50}); lowest dose at which toxic effects are observed in an individual (TD_{Lo}); and lowest concentration at which toxic effects are observed in an individual (TC_{Lo}). Typically, these doses are designated as being administered via the oral, inhalation, dermal, or ocular routes and are expressed as a mass of contaminant per mass of body weight. The toxicity of a chemical, as well as the resulting adverse health effects, depends on the route of exposure. The toxicity values may also be time dependent (i.e., the lethal dose or concentration will change depending on the time period over which exposure occurred). When human estimates for these parameters are available, they should be used, but in most cases it will be necessary to use data from animal studies. When data from animal studies are used, the type of animal used should be considered when estimating the concentrations that will cause health effects in humans. In addition, several methods are used to extrapolate the data to humans, including multiplying values by safety factors to account for genetic and physiological differences and susceptible populations. Furthermore, it is important to consider that sensitive populations may experience adverse health effects at levels significantly below the reported toxicity values.

Table 5-4. Properties Applicable to Chemical Contaminants

Property	Discussion
Hydrolysis	Hydrolysis is the reaction that occurs between a chemical and the ions in water (H^+ and OH^-), which may produce byproducts that are less toxic than the parent chemical. However, it is important to consider the toxicity of the hydrolysis products, as some can be highly toxic themselves. The hydrolysis half-life of a chemical is the time required for the concentration to be reduced to ½ the initial concentration as a result of hydrolysis reactions. Contaminants that are resistant to hydrolysis have longer half-lives in water, and thus may be of greater concern due to their persistence. For example, if a contaminant has a half-life in water of 8.5 hours, it would have less long-term contamination impact than a contaminant with a half-life of 8.5 weeks.
Reactivity	The reactivity of a contaminant is a function of how quickly it will undergo chemical change, in this case in an aqueous system. Reactive compounds will rapidly undergo reactions such as oxidation or hydrolysis. Reactivity will typically depend on environmental variables such as temperature, pH, type of disinfectant, and the presence of any materials that might catalyze (speed up) or inhibit the reaction. A less reactive compound would undergo oxidation or hydrolysis at a slower rate, or not at all. Thus, reactivity will determine how quickly contaminants in a water distribution system will break down.
Solubility	Solubility is the amount of material that will dissolve in water under specific conditions of pH, temperature, and dissolved solids concentration. Contaminants that are insoluble in water may be removed by conventional treatment processes if they are introduced upstream of the treatment plant. If introduced into the distribution system, insoluble chemicals may precipitate and settle out in the pipes and joints, potentially reducing the public health consequences due to the reduced concentration in water. However, compounds with limited solubility that deposit on pipe materials may present a greater remediation challenge (see Module 6).
Implications of Oxidation	Oxidation is a chemical reaction process in which there is a loss of electrons from an atom or ion. Drinking water is often treated through the addition of an oxidizing agent (e.g., chlorine, chlorine dioxide, ozone, etc.) to accomplish disinfection. In this process, pathogens are inactivated through damage to the cell wall, and alteration and deactivation of the cell enzymes. Chemical compounds may also react with oxidizing agents. In some cases a sufficient oxidant concentration will fully break down chemical compounds to basic constituents such as carbon dioxide, water, or elemental nitrogen. In other cases such as phenol, low concentrations of oxidants such as chlorine will produce halogenated compounds, which may be more toxic than the original compound.
Volatilization	In an open system, such as a reservoir, the concentration of a volatile contaminant may be reduced as it evaporates into the atmosphere. However, while within the contained and pressurized portion of a water distribution system, volatilization is not expected to be a significant fate and transport process. Volatility is also a factor to consider during an assessment of potential public health consequences. Specifically, volatile chemicals are more likely to pose a threat to public health through inhalation and dermal pathways (e.g., while showering).

Table 5-5. Properties Applicable to Biological Contaminants

Property	Discussion
ID_{50} and Minimal Infective Dose (MID)	The infectious dose for 50 percent of the population (ID_{50}) can be used to estimate the concentrations at which a significant portion of the exposed population (50% or greater) would develop disease. When human estimates for these parameters are available, they should be used, but in some cases it will be necessary to use data from animal studies. When data from animal studies are used, the type of animal used should be considered when estimating the number of pathogens necessary to cause disease in humans. Furthermore, it is important to consider that sensitive populations may develop the disease at exposures significantly below the ID_{50}. The minimal infective dose (MID) is the minimum number of pathogens required to infect an individual, and may be significantly lower than the ID_{50} for susceptible individuals.
Disease and Death Rates	The disease rate, or morbidity, is the rate of occurrence of a disease in individuals exposed to the pathogen. The death rate, or fatality, is the percentage of people infected who will likely die as a result of the disease. For example, plague is nearly always fatal unless treated within 12 to 24 hours, and thus has a fatality rate near 100%. Estimates of these rates may be important in determining the impact of the contaminant on public health and the additional burden that critical care facilities may face as a result of the incident.
Secondary Transmission	Some pathogens can be transmitted from person to person (i.e., a contagious disease), making direct exposure to the contaminated water unnecessary for infection. Thus, a terrorist attack with a non-contagious agent would be self-limiting, whereas an attack with a contagious agent could trigger an epidemic. Knowledge of this property will help determine whether public health responses beyond notification, such as patient quarantine, are necessary. For example, smallpox is a contagious disease with fairly high rates of secondary transmission, while anthrax is non-contagious.
Survivability in Water	The length of time that pathogens can survive in water and/or their capability to reproduce in water can contribute to the severity of a water contamination event. For example, pathogens that can survive for months or longer in spore or cyst form will pose a greater public health and remediation challenge than those organisms that can survive for only hours or a few days in water. In addition, pathogens that are capable of reproducing in water may have a longer-term impact than those that need a host or other conditions to reproduce.
Susceptibility to Disinfection	Generally, organisms that are susceptible to chemical disinfection pose less of a threat than those that are resistant to commonly used drinking water disinfectants. However, some disinfectants, such as ozone, UV, and chlorine dioxide, are only used in the plant and would not be effective against any contaminants introduced post-treatment. The maintenance of a chlorine residual in the distribution system provides some protection against contaminants that are susceptible to inactivation by low levels of chlorine. If biological contaminants that are more resistant to disinfection are detected, they may be inactivated by more aggressive disinfection practices as part of the remediation process (see Module 6).

Some of the information and data listed in Tables 5-3, 5-4, and 5-5 can be found in the following sources; however information about all items listed will likely not be available for each contaminant.

- US EPA Water Contaminant Information Tool (WCIT), which is being developed specifically for the water sector and is described in Module 2, Appendix 8.9 (US EPA, in preparation)
- US EPA's List of Drinking Water Contaminants & Maximum Contaminant Levels (MCLs): http://www.epa.gov/safewater/mcl.html#mcls.
- Agency for Toxic Substances and Disease Registry (ATSDR): www.atsdr.cdc.gov.
- CDC Emergency Preparedness and Response: www.bt.cdc.gov.
- Recognizing Waterborne Disease and the Health Effects of Water Pollution: A Physician On-line Reference Guide: www.waterhealthconnection.org.
- Physician Preparedness for Acts of Water Terrorism: www.waterhealthconnection.org/bt/index.asp.
- Registry of Toxic Effects of Chemical Substances (RTECS): www.cdc.gov/niosh/rtecs.html.
- Risk Assessment Information System (RAIS), which contains information taken from the US EPA Integrated Risk Information System (IRIS), the *Health Effects Assessment Summary Tables* (HEAST-rad HEAST-nonrad), US EPA Peer Reviewed Toxicity Values (PRTVs) Database, and other information sources: http://risk.lsd.ornl.gov/index.shtml.
- United States Army Medical Research Institute of Infectious Diseases (USAMRIID) Medical Management of Biological Casualties Handbook: http://www.usamriid.army.mil/education/bluebook.html.
- WaterISAC, which contains information on contaminants including various contaminant fact sheets as well as the United Kingdom Water Industry Research (UKWIR) database: www.waterisac.org.
- World Health Organization (WHO): www.who.int/search/en/.
- WHO's "Public health response to biological and chemical weapons" www.who.int/csr/delibepidemics/biochemguide/en/index.html.

As a final note, the information described in the tables above can be used not only to determine the level of threat that contaminants pose to water users, but also to aid in determining the type of response actions to take in the event of a contamination incident. Of particular importance are fate and transport processes that impact the persistence of a chemical contaminant in the water system. As shown in Table 5-4, the rate of hydrolysis of a contaminant is a parameter that has a significant impact on the amount of time that it will remain in the water system at concentrations of concern and, therefore, might influence the response decision. For example, if the identified contaminant rapidly hydrolyzes under typical drinking water conditions (i.e., has a relatively short half-life), the response action may be to simply restrict water use for a sufficient time, monitor the system to determine that the contaminant has fully degraded, and return the system to normal operation once the monitoring has demonstrated that the contaminant has degraded to acceptable levels.

3.2 Assessing the Spread of Contaminant in the System

The ability of a water utility to assess the spread of a contaminant in its water supply system depends largely on its understanding of the system hydraulics and operation. The drinking water utility is in the best position to characterize its system design and operation, flow and pressure patterns, and containment options. It is recommended that every utility perform a hydraulic assessment of its distribution system in order to better understand the potential spread of a

contaminant **before** an actual water contamination threat or incident. This type of analysis will facilitate an appropriate and timely response when a threat or incident actually occurs.

Information from a hydraulic assessment conducted by the water utility can:

- Facilitate the identification of available containment options.
- Assist in developing procedures for selecting and implementing the most appropriate containment option.
- Provide information necessary to make decisions regarding public health response actions, specifically identifying the area of the distribution system that would be subject to water use restrictions.
- Assist in identifying locations at which sampling and analysis may be most useful, thus reducing the amount of testing (and associated cost) that is required.
- Target *"reverse 911"* messaging to a specific area (i.e., calls are made to businesses and residences in the defined risk area notifying recipients of the public health danger that is present and providing them instructions for protection).
- Help in identifying feasible locations and methodologies for injection of disinfection to inactivate or reduce the threat posed by the contaminant.
- Support the system characterization phase of the remedial process (see Module 6, Section 3.2).

Two types of methods (namely, manual assessment methods and modeling) for assessing the spread of a contaminant in a distribution system are described below. The methods selected for use by specific water utilities will vary depending on their financial resources, size and characteristics of the system (i.e., number of pipes and nodes), and staff availability for training and utilization of the tools.

3.2.1 Manual Assessment Methods

Manual methods for assessing the spread of a contaminant are based primarily on the hydraulic operation of a system and use the utility's knowledge of flow patterns and pressure zones in its system. The results of this hydraulic analysis, when combined with maps or other geographical and population information, can be used to estimate and identify the population potentially affected by a suspected contamination incident.

Much of the current literature regarding water distribution system assessment focuses on the use of computerized models. Such models certainly provide useful capabilities, especially for large and complex water systems. However, manual assessment methodologies continue to have advantages, particularly for small systems. These methods are often more efficient and cost effective. In addition, such methods avoid several of the potential drawbacks of more sophisticated computer-based methods. First-time users of any software often become absorbed in learning to successfully operate the software and, therefore, may not focus on the technical substance underlying their efforts. Manual methodologies have the potential benefit of allowing water system operators and engineers to focus primarily on understanding their system's critical operating characteristics. For many small systems, use of computerized modeling may require outside assistance in the form of a consultant. Depending on how involved the system's staff is in the ensuing evaluations, this may result in the consultant acquiring a greater understanding of

the system than the operating staff. Unfortunately, the consultant's staff may not be available when a contamination threat or incident arises.

In using manual methods, various types of scenarios should be created, to assist the utility in better understanding the range of flow and pressure patterns under various demand conditions that may be encountered during a contamination threat or incident. Examples of demand condition scenarios to be considered in the evaluation might include:

- Average day demand – Use the ratio of unaccounted for or leaked water to raise all demands such that total demand equals total water pumped.
- Peak demand – Estimate the ratio of peak day to average day demand from pumping records.
- Low-use day demand – Estimate the ratio of winter/low day to average day demand from pumping records.
- Variations in demand or flow patterns over the course of a 24-hour day (e.g., night versus day, morning and evening peaks versus average flow during the day) – Consider variations within each of the three scenarios described above.

Factors that will impact system behavior under various scenarios will include basic system configuration and hydraulic characteristics (pipe sizes, use of booster pumping stations, etc.), physical ability to isolate portions of the system using existing control structures, and system topography. In particular, relative line elevations will control the effects of any attempt to depressurize all or portions of the system, by possibly creating various isolated zones once the system is depressurized. Consideration of these characteristics under the various types of scenarios described above may reveal possible containment strategies that might be effective in response to various threat scenarios.

In general, the utility should strive to identify demand scenarios that will, to the extent possible, define the range of system behavior. For example, in a particular system, if daily cycles in water usage patterns result in reversal of flow in certain lines, response and recovery plans for those portions of the system should include consideration of the conditions that determine flow and include appropriate actions for both conditions.

Utilities may find it useful to develop a list of typical travel times from a reasonable number and spatial distribution of possible contaminant introduction points to large population centers or critical customers. Utilities may also apply basic hydraulic engineering methods, such as simple network analyses, to understand how water moves through their system during different circumstances. These simple analyses (often carried out using simple spreadsheet software primarily for convenience) allow the utility to estimate the likely spread of a contaminant under the known conditions of a hypothetical contamination incident. In situations where potential water contamination incidents are reported from public health surveillance (i.e., emergency room visits, hospital admissions, and disease reporting to public health agencies), the water utility can compare case density and location to distribution system maps. Large-scale maps can be created showing locations at which exposure is suspected (e.g., points of ingestion or other use) and likely introduction points of a contaminant. This information can facilitate the identification of affected areas and be used to guide initial public health response actions. As noted in Section 2.1, difficulties in data sharing between the public health agency and the utility should be

resolved during public health response planning. One example of how the public health agency and utility may resolve these challenges is to have the public health agency lead the assessment with input from the utility, thereby protecting patient information.

3.2.2 Water Distribution Models

In conjunction with the manual assessment methods, water distribution models can be used to provide additional information to predict the dispersion and dilution of a contaminant as it travels through the water distribution system. As with the manual assessment methods, water distribution system models may be run under various demand conditions to simulate the expected range of flow and pressure patterns in a system. Water distribution modeling should be performed as part of planning for a response to a water contamination incident.

A variety of water distribution models with various features are available. These are described below.

- The simplest of these are steady-state models. These basic models only allow for the analysis of flow under steady-state conditions (i.e., all flow rates are constant). While such conditions never really occur in an actual system, the analyses carried out using such models can provide a basic understanding of distribution system hydraulics. This is particularly the case for smaller, less complex systems.
- Dynamic models allow the more realistic simulation of changing flow conditions over time. As such, these more complicated models allow more realistic simulations of flow conditions in an actual system. The disadvantage of such models is their increased complexity and required level of expertise. They also require substantially more field data in order to be calibrated.

Both steady-state and dynamic models can be enhanced with the following capabilities:

- Water quality modeling capability allows a model to simulate dilution and production/decay of contaminants in the distribution system. This advanced feature should provide a better estimate of the contaminant concentration at any time or location in the system during an event. When using water quality modeling as a risk assessment tool, modelers should be very conservative in their use of inactivation/decay rates because the misuse of these rates can cause the model to significantly underestimate the contaminant concentration actually present in the water.
- Linkage to GIS allows model input and output to be easily and quickly linked to actual geographical areas and specific customers. GIS can provide users with an immediate visual graphic to locate areas of high contamination or low flow. For example, an ArcView shape file (i.e., *.shp) can be created with locations keyed to account numbers and nodes or model junctions from AutoCad.

These models allow a water utility to:

1. More readily assess the consequences to the population and infrastructure within the area suspected of being contaminated.
2. Examine the effects of isolating portions of the system by closing valves to prevent the spread of a contaminant.

3. Identify existing isolation options and potential modifications to the system that may increase or enhance the existing options.
4. Identify distribution options for providing an isolated area with water from adjacent areas or pressure zones.

Most distribution system models are used just for hydraulic assessments, and only a limited number have a water quality component that could be used to simulate a contamination incident. However, if the distribution system model has the ability to consider contaminant properties that impact fate and transport, water utility users can also simulate the fate and transport of contaminants introduced into the distribution system. Again, modelers should be conservative in their use of inactivation/decay rates to avoid significantly underestimating the concentration of contaminants.

For example, a pipe network hydraulic model, such as the industry standard EPANET, can perform extended period simulations (EPS) of hydraulic and water-quality behavior for water distribution systems. EPS are not steady-state, but rather dynamic models that change over extended periods. The program tracks the following for multiple time steps:

- The flow of water in each pipe.
- The pressure at each node.
- The water level in each tank.
- The concentration of chemical species throughout the network.

EPS accomplish this by continuously utilizing information from a number of time-variable factors, such as tank water levels, pump operation, and demand fluctuations. EPS can only calculate the concentration of chemical species if the decay parameters for the contaminant are known. However, for most contaminants, the decay parameters are unknown, and it is safer to assume no decay as a conservative approach.

EPS can be more accurate than steady-state models because typical system velocities range from about 0.1 to 10 feet per second, so contaminants can take hours or days to migrate through a distribution network. Additionally, system demands vary throughout the day, which cannot be accounted for in steady-state models.

EPANET is public domain software that may be freely copied and distributed. Other similar models that could be used in this capacity include, but are not limited to:

- MWH Soft H_2ONET (www.mpact.com/page/p_product/net/net_overview.htm)
- KYpipe PIPE2000 (www.kypipe.com)
- AdvanticaStoner SynerGEE Water (www.advantica.biz/stoner_software/synergee_water/)
- Haestad Methods WaterCAD ™ (www.haestad.com/water/default.asp)
- PipelineNet (http://eh2o.saic.com/iwqss/)
- DH1 Software Mike Net (http://www.dhisoftware.com/mikenet/).

Note: The mention of these commercially available models is for illustrative purposes and does not imply endorsement by the US Government.

If calibrated and validated properly, the more sophisticated models can enable water utilities to simulate contamination incidents more accurately. Generally, these programs are able to import database files from spreadsheets, database applications, and other models. The benefit of these more sophisticated models is their ability to model contaminant spread on a near real-time basis. As an example, Appendix 8.7 describes the capabilities of PipelineNet, a complex model that was specifically developed to estimate the consequences of a terrorist incident on a city's drinking water infrastructure. This model incorporates census population information to help assess total population at risk, including sensitive populations at hospitals and schools.

Users should be able to use these more complex models to input points of contaminant introduction and simulate downstream affected areas, possible containment strategies, and potential points of disinfectant injection. These models allow the user to simulate the spread of a conservative tracer, like dye, through parts of the distribution system under various conditions. In addition, the user can simulate disruptions to critical system components and then evaluate different types of operational response options to deal with the lose of the component. Several models can also track the spread of multiple constituents introduced at different points in the network.

Computerized models can provide powerful analytical tools, particularly for large, complex water distribution systems. Nonetheless, like any tool they are not needed by all systems, and in some cases their drawbacks may outweigh their advantages. As noted above, for small simple systems, manual evaluation methods may be more efficient. Furthermore, model users may fail to adequately scrutinize model results, due to the seemingly definitive and complex outputs of may computer models.

In addition, to providing reliable results, models need to be "calibrated" and "validated" using actual system flow and pressure data. Failure to carry out adequate calibration and validation activities can result in a model that is not representative of system operating characteristics, which could lead to the development of ineffective response strategies.

4 Operational Response Options

As discussed in Module 2, the objective of *immediate operational response* actions is to minimize the potential for exposure of the public to the suspect water, as well as provide additional time to evaluate whether or not the threat is 'credible'. Because these response actions may limit public exposure, they may also be considered an effective public health response. Operational response actions are typically suitable for implementation early in the threat management process, assuming that they will have minimal impact on the consumers. In general, containment will be the most likely option for an operational response, but other novel operational response options such as elevation of the disinfectant levels in a targeted area of the distribution system may be considered. Issues related to planning for, and implementation of, operational responses are discussed in this section. Note that distribution system flushing is not addressed in this Module as a potential public health response due to the ramifications of discharging potentially contaminated water. Module 6, Section 4.1.2 discusses distribution system flushing as a potential remedial action.

4.1 Containment of Suspect/Contaminated Water

Containment of contaminated water may be an appropriate immediate operational and public health response action, especially when at the 'possible' stage of the threat management process. The objectives of containment are to 1) prevent the spread of the contaminant to as yet uncontaminated sections of the system and 2) to the extent possible, preclude system users from drawing the contaminated water from the system. The decision to contain the water needs to be made quickly for the measure to be effective and should involve the appropriate agencies as identified during the planning process. The decision process for implementing containment is shown in Figure 5-2 and also discussed in Module 2. There are three key decision points in the process: 1) Can the area potentially affected by the contaminant be estimated? 2) Is it physically possible to contain the affected area? and 3) To what extent will containment negatively impact consumers and/or fire protection? The "Consequence Analysis," which deals with the number of individuals affected, health effects on consumers, and impacts of response actions, will influence the evaluation of potential containment options. It is important to note that the fire department should always be contacted prior to implementing containment if the act of containment would impact firefighting capability in the area. Module 2, Section 2.3 describes a general approach for consequence analysis, while Section 3 of this module provides additional detail for assessing the public health consequences associated with a particular contaminant.

When responding to a contamination threat at the 'possible' stage, implementation of containment options may be limited by consideration of the impacts of containment on consumers or firefighting (as shown in Figure 5-2). If containment would have substantial, adverse impacts, it may be prudent to accelerate the threat evaluation to establish whether or not the threat is 'credible' such that a decision can be made regarding the implementation of a containment strategy. On the other hand, once a threat has been deemed 'credible', the most appropriate option may be to implement the containment strategy and manage the resulting impacts. In other words, the impacts of containment on consumers and/or fire protection may not be as critical if the contamination threat has been deemed 'credible'. In addition, if a containment strategy was already implemented during the 'possible' stage, expanded containment strategies might be considered at the 'credible' stage.

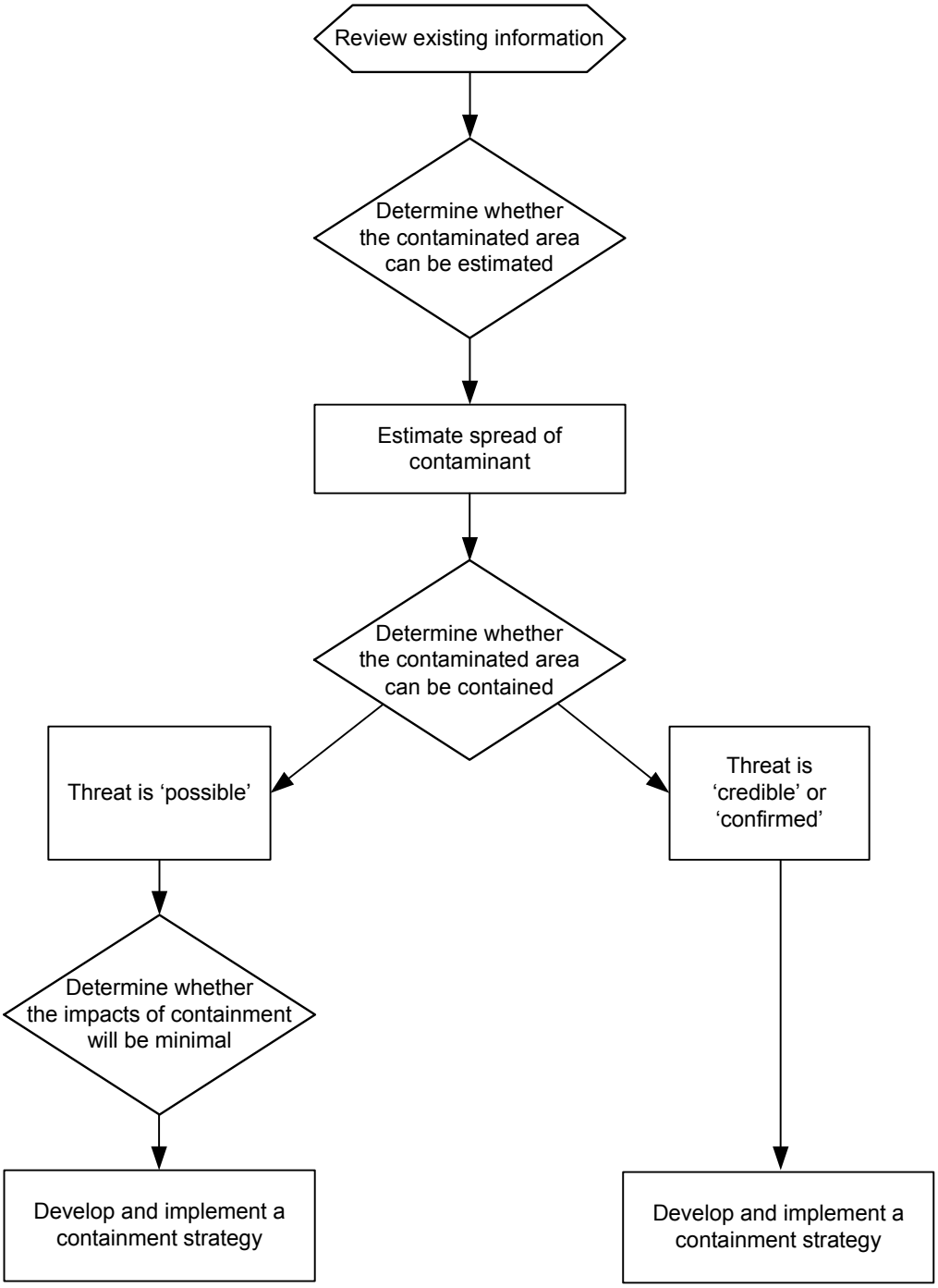


Figure 5-2. Decision Process for Containment as a Public Health Response

If there are consumers within the isolated area, it will likely be necessary to notify them of any restrictions regarding use of the water (i.e., public notification) and possibly provide them with

an alternate supply of drinking water. Public notification and provision of a short-term alternate water supply are discussed in Sections 5 and 6, respectively.

In preparing for the use of containment as an operational response, water utilities can use either manual methods or computerized hydraulic models coupled with GIS (discussed in Section 3.2) to estimate areas of their systems that could be affected by contamination, detect vulnerabilities in a water distribution network, and identify possible containment strategies **prior to** the occurrence of a water contamination threat. Using either manual methods or hydraulic models as a means of understanding system hydraulics should generally be considered a planning tool that will help the water utility understand the implications of containing various areas of the system, allowing for a prompt and informed response to contamination threats.

Containment or isolation is generally accomplished by closing specified valves in the network to create a closed loop or to stop the flow from one segment of the distribution network to another. However, utilities should be cautious when isolating a portion of the system with valves because the valves could leak making it unclear whether the contaminated water has been effectively contained. Other containment options might include hydraulically created reverse flow conditions or bypassing a segment of the network. Familiarity with the system dynamics such as knowing direction of flows (under specific circumstances) and various loops and location of isolation valves will increase the likelihood of a prompt and effective response.

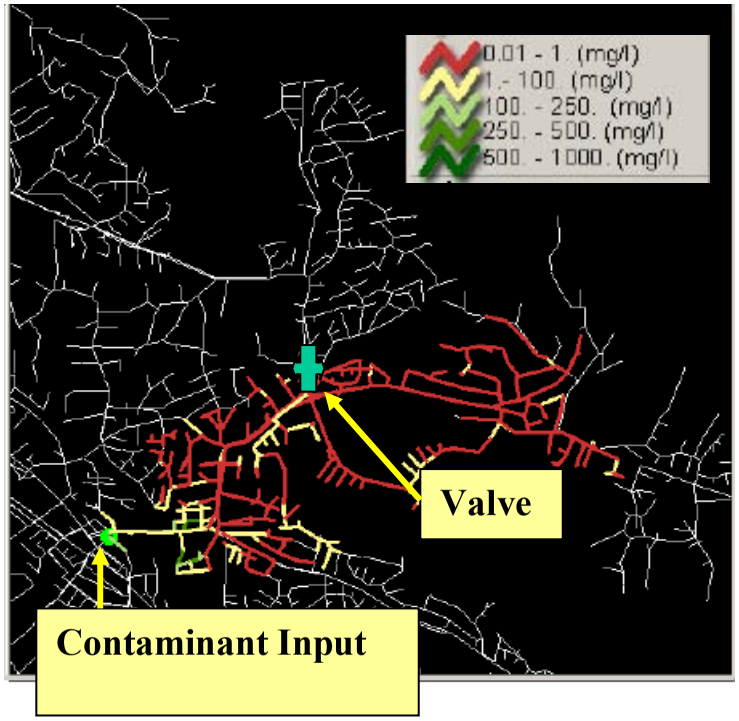
Situations in which containment is likely to be feasible include those in which a specific *contamination site* has been identified and can be easily isolated without significant impact to normal operation of the system. As an example, some distribution system storage tanks may be isolated using valves with minimal impact on system pressure and operation.

A more complicated situation arises when the suspected point of contaminant introduction is directly into a main or service line. In this situation, the utility may wish to physically prevent customers from drawing water, which would entail dispatching crews to close isolation valves or service line meter stops for each customer.

Figure 5-3 illustrates the potential effectiveness of isolation via a valve closure. The two graphics compare the spread of the contaminant, after 24 hours, through a portion of a hypothetical distribution system with the indicated valve open in one case and closed in the other. The pipe colors show contaminant concentration. In this case, closing the valve successfully prevents the spread of the contamination to the northern section of the distribution system. The hydraulic model output provides both spatial and temporal information on the dispersion of the contaminant.

For smaller systems there may be only a limited number of isolation options. For such systems, evaluation of potential containment strategies under a limited number of typical and critical conditions will often be sufficient to assess the viability of a particular isolation option. As with systems using computerized models to assess response options, the important point is to identify viable actions and to clearly define the conditions under which an action will be effective and appropriate before an incident actually occurs.

Valve Closed



Valve Open

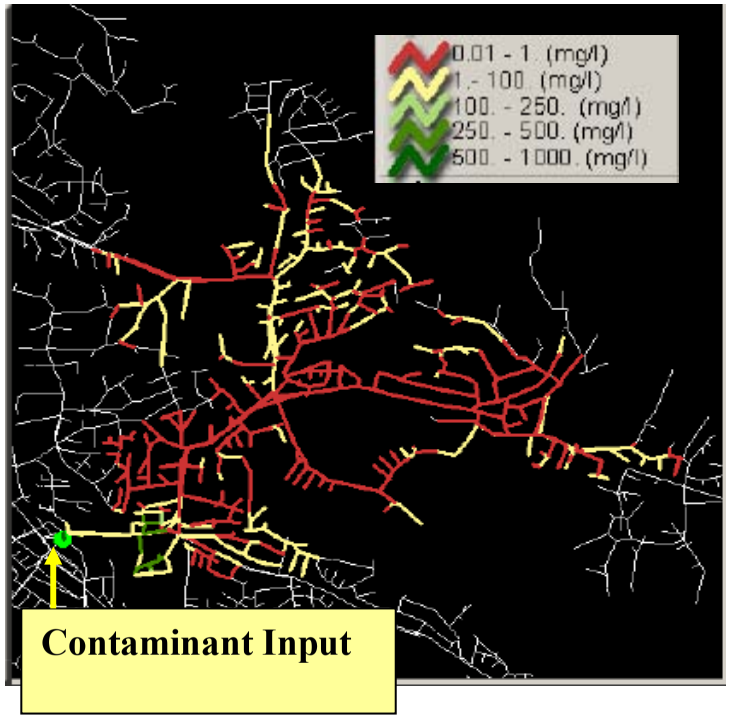


Figure 5-3. Comparison of Contaminant Spread With and Without Valve Closure.

4.2 Novel Operational Responses to Contamination

Intentional drinking water contamination incidents present the drinking water industry with a series of challenges, and current capabilities and practices may in some cases be insufficient. As a result, efforts to develop effective response measures and tools may at times require the development of new practices and equipment. The concepts discussed briefly below are not specifically recommended for any particular system. Instead, these as-yet untried measures are intended to illustrate the potential for "thinking outside the box" in developing approaches to responding to the new challenges posed by drinking water contamination threats and incidents. It is critical that novel approaches, such as those discussed below, only be considered if approved by the drinking water primacy agency.

One possible immediate operational response is increasing the level of disinfection at the treatment plant and/or injecting disinfectants in close proximity to the contaminants. Neither method is likely to adequately treat the water to allow the public to consume the contaminated water within the distribution system, but the elevated disinfection levels may aid in system remediation efforts, and may help in limiting the volume of contaminated water to be handled during remediation.

Manual or hydraulic assessment methods may provide a means of estimating the efficiency of adding disinfectant at various locations in the system. Utility operators can then compare scenario results and implement the most effective treatment. Injection of a disinfectant as an operational response at locations where disinfection currently does not take place would require the development of mobile disinfection capability. A mobile system would likely make use of an existing service connection for most systems, and there would be a need to train staff in its application. Most drinking water primacy agencies recommend or require the use of chlorine for emergency disinfection of the public water supply; thus some systems may already have some mobile disinfection capability.

To address instances of contamination of storage tanks or reservoirs, one challenge may be to rapidly and effectively disinfect the entire tank volume. The development of equipment to allow the rapid addition and mixing of disinfectant should be possible and may involve the use of portable equipment involving multi-port diffusers and a mixing capability.

In addition to chlorine, another potentially useful measure may be the point injection of food-grade colorants or dyes into the distribution system. The injection of the dye may discourage public consumption of the potentially contaminated water and act as a second layer of protection in addition to public notification. As with point injection of a disinfectant, this approach would require a thorough understanding of system hydraulics, such that the target areas are covered by the response.

Another response may be to reduce the pressure in all, or at least a portion of a system. This would reduce water availability to customers, and potentially facilitate containment measures. Depressurization could also have potentially serious hydraulic (possible damage to system components due to water hammer and related effects) and public safety (firefighting) consequences. Such consequences would need to be carefully considered prior to implementation.

5 Public Notification Strategy

The public notification strategy is a key component of public health response. Once it has been decided to implement public notification, the water utility and other appropriate agencies should be prepared to quickly and effectively issue the appropriate public notices. This section covers all of the essential components of a public notification strategy including the process of deciding when to issue a public notice; the type, format, and content of a public notice; the target audience for the public notice; and methods for delivering the notice.

It is important to note that public notification in response to a water contamination threat or incident may be required under the PN Rule (40 CFR Part 141, Subpart Q). Specifically, this rule may require public notification in a "situation with significant potential to have serious adverse effects on human health as a result of short-term exposure" as determined by the primacy agency in its regulations or on a case-by-case basis [141.201(b)]. In the PN Rule, this is called a Tier 1 public notice. The Tier 1 public notice requirements address who must be notified, when the notification must take place, and the required form and manner of the public notice. In responding to a 'credible' contamination threat, the utility needs to consult with the drinking water primacy agency, and potentially the public health agency, to determine whether or not the situation warrants public notification (in compliance with the Tier 1 public notice requirements in the PN Rule). If it is determined that the situation is subject to the PN Rule, then the water utility is required to ensure that the public notification complies with the requirements in the PN Rule. Throughout this section, the specific Tier 1 public notice requirements are presented where appropriate. Additional guidance regarding public notification and the requirements of this rule can be found in the "Public Notification Handbook" (US EPA, 2002a).

5.1 How to Decide What Type of Public Notification is Appropriate

This section describes the decision process for implementing public notifications in the overall context of threat management. Figure 5-4 illustrates an example decision process for public notification.

The decision process begins with an evaluation of threat credibility and the potential consequences to public health to determine if public notification is an appropriate response action. The first decision point in Figure 5-4 considers the operational response actions taken at the 'possible' stage (described in Section 4 of this module) and evaluates whether or not these actions are adequate to protect public health. If they are, then it may not be necessary to consider public notification. For example, if the suspect water has been confined to a tank, with some degree of confidence that the water has not spread beyond the tank, containment may provide adequate public health protection. However, if the operational response actions are determined to be insufficient to prevent or limit exposure, then public notification should be considered. Any decisions to issue public notification should be made in consultation with decision officials from the appropriate regulatory agency, such as the drinking water primacy agency and/or health department. (These agencies should have been identified in the Public Health Response Plan as well as the water utility's ERP.)

Arrangements need to be made with these organizations prior to an incident in order to establish clear lines of communication, develop templates for notification, and ensure access to decision officials on a 24/7 basis.

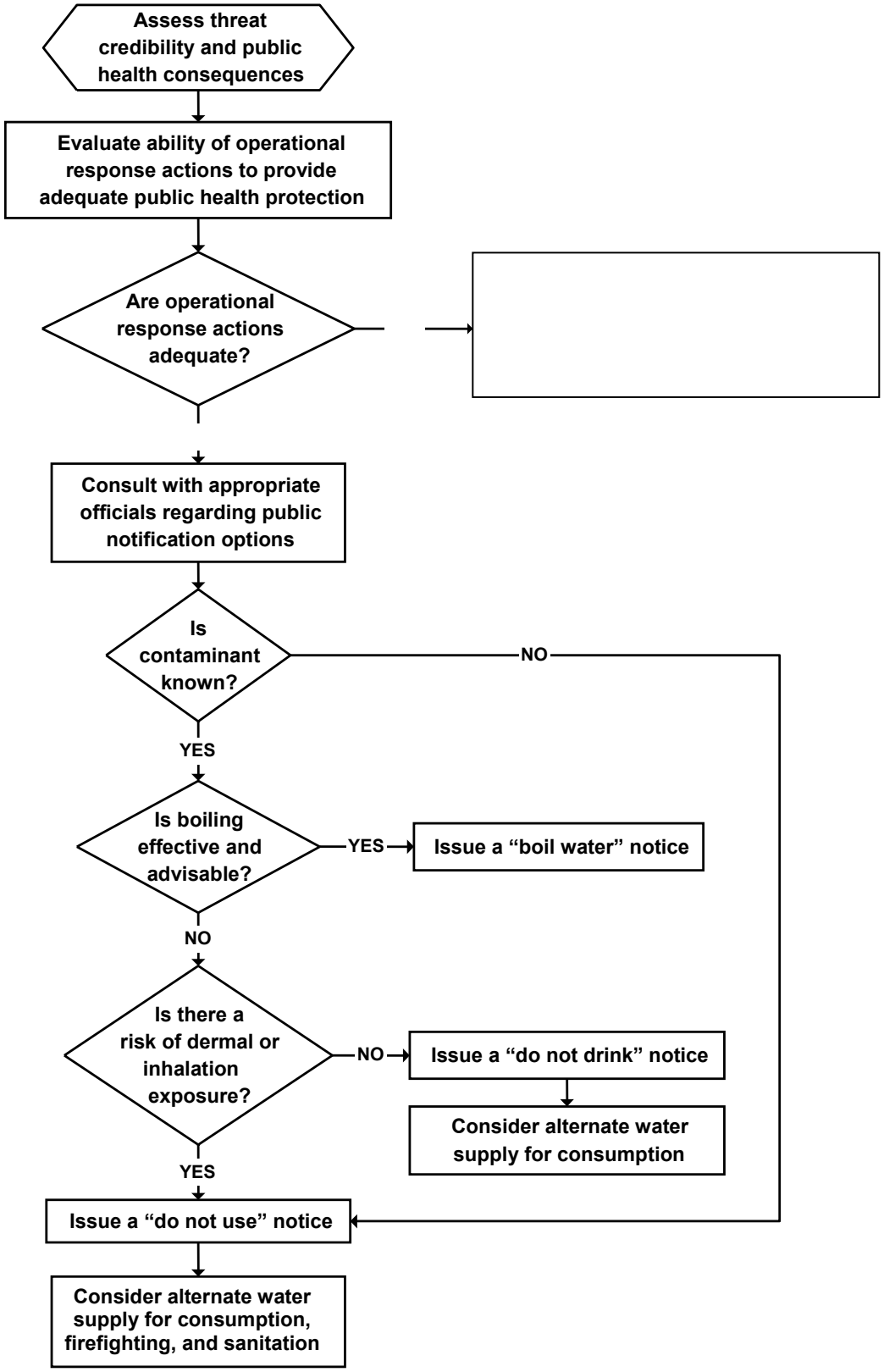


Figure 5-4. Example Decision Process for Public Notification

For a Tier 1 notification under the PN Rule, which is required for situations with significant potential to have serious adverse effects on human health as a result of short-term exposure, the utility must:

1) Provide a public notice as soon as practical, but no later than 24 hours after the system learns of the violation (or credible contamination threat);
2) Initiate consultation with the primacy agency as soon as practical, but no later than 24 hours after the public water system learns of the situation, to determine additional public notice requirements; and
3) Comply with any additional public notification requirements (including any repeat notices or direction on the duration of the posted notices) that are established as a result of the consultation with the primacy agency. Such requirements may include the timing, form, manner, frequency, and content of repeat notices (if any) and other actions designed to reach all persons served.

Once a decision has been made to consider public notification as a means of limiting exposure, it is necessary to evaluate the level of notification appropriate for the incident (i.e., the level of restrictions on water use that are necessary to protect the public). As indicated at the second decision point in Figure 5-4, any available information about the suspected contaminant will support the evaluation of notification options. If the identity of the contaminant is unknown, it may be necessary to adopt a conservative approach and issue a "do not use" notice, which will limit the potential for exposure via any route (but will also create the greatest burden on the community). If the identity of the contaminant is known with a sufficient degree of confidence as a result of the threat evaluation, then the public notification may be crafted to deal with the specific risks to public health posed by the contaminant (discussed in Section 3 of this module). For example, if boiling will easily destroy the contaminant without creating additional hazards through aerosolization, then issuance of a "boil water" notice may be preferred. If boiling is not an option, but the contaminant does not pose a risk through inhalation or dermal exposure pathways, issuance of a "do not drink" notice may be appropriate. A "do not drink" notice should restrict all use of the water in which ingestion is possible (i.e., the water should not be directly consumed or used in food preparation). Finally, if there is a risk to public health through inhalation or dermal exposure, or if the risk of exposure via these pathways is unknown, then a "do not use" notice should be considered. By considering these notifications in a progression from the least to greatest burden on a community, the impact on the public should be minimized while still making public health protection the priority consideration.

Figure 5-4 indicates that if the public is asked not to drink or use the water, then the response should also consider provisions for an alternate drinking water supply. If the restriction is only on consumption, then the suspect water can still be used for all other activities that do not involve ingestion of the water (e.g., flushing toilets), and it will only be necessary to provide an alternate drinking water supply for consumption and related activities such as food preparation. A "do not use" notice is much more restrictive, and decision-makers should consider how other needs of the community, such as sanitation and firefighting, will be met. The planning and preparation for short-term provision of water that may be necessary if restrictions are placed on drinking water usage are described in Section 6 of this module.

5.2 Target Audience

For notification under the PN Rule, the utility must provide public notice to persons served by the water system and to the owner or operator of any consecutive systems. Persons served by the water system include renters and transient populations in addition to billed customers. If the utility has a credible contamination threat or incident in a portion of the distribution system that is physically or hydraulically isolated from other parts of the distribution system, the primacy agency may allow the system to limit distribution of the public notice to only persons served by the portion of the system that is out of compliance. Permission by the primacy agency for limiting distribution of the notice must be granted in writing. The utility should also consider notifying mobile users of the water supply, such as airplanes or cruise ships that may have filled up with water from the area during the contamination event and traveled away from the area prior to notification.

In addition, when the water utility is identifying the list of entities to be notified during a water contamination threat or incident, customers with special needs should be considered. The water utility should maintain a list of customers with special needs as part of its ERP. Some of these users should be given priority notification due to their public health mission and/or because they may serve customers considered to be 'sensitive subpopulations' (e.g., children or the elderly). Specific notification procedures should be developed for these entities and those with special communication needs (see Section 5.3.3 of this Module for information regarding procedures for customers with special communication needs). These lists and procedures should be coordinated with the local public health department and the local health officer. The following list includes some customers with special needs served by the water system that may require immediate notification. Using this list as a guide, each utility should develop, during planning, its own list of specific customers with special needs:

- Critical care facilities
  - Hospitals
  - Clinics
  - Nursing homes
  - Dialysis centers
- Schools
- Day care facilities
- Businesses
  - Food and beverage manufacturers
  - Commercial ice manufacturers
  - Restaurants
  - Agricultural operations
  - Power generation facilities
  - Any other businesses identified by the water utility.

5.3 Content and Format of the Public Notification

Once the decision has been made to issue public notification as a public health response, the details of the instructions and information to be provided to the public need to be crafted. The general content and format for various public notices should be developed as part of planning – not during a crisis. These general templates can then be quickly customized according to the details of a specific situation. The water utility should work with appropriate public health officials to determine the

specific information and instructions to communicate in the notice as well as the format and means of dissemination.

5.3.1 Content

For notification required under the PN Rule, the utility must send a copy of the notice to the primacy agency.

The PN Rule requires that the following elements be included in a public notice:

- A description of the incident, including a description of the contaminant(s) and information regarding how the contaminant(s) entered the water (if this information can be shared).
- When the incident occurred.
- Potential adverse health effects.
- Population(s) at risk.
- Whether alternate water supplies should be used. If alternate water supplies should be used, the utility should consider listing the locations at which these alternate supplies are being provided.
- Actions consumers should take (e.g., do not use, do not drink, conserve water). **NOTE:** When issuing a boil water notice, the notice should include specific instructions for boiling the water (e.g., how long the water should be boiled) because of differences in the effect that boiling has on various potential contaminants as well as differences in recommended boiling times based on altitude. It is critical to confer with the drinking water primacy agency and health department prior to issuing a boil water notice to determine the appropriate instructions. Whenever possible, a standard (and conservative yet reasonable) boiling time should be adopted as a part of planning to reduce any confusion during an actual water contamination incident or threat.
- When consumers should seek medical help, if known (e.g., "If you have been exposed and are experiencing severe flu-like symptoms, call 911; if symptoms are mild contact your physician for assistance.")
- Actions that are being taken to correct the situation. The utility should consider including information about how the utility, public health agencies, and law enforcement agencies are responding and if and why protection measures have a limited effectiveness.
- The expected duration of the emergency.
- Name, business address, and phone number for additional information.
- Standard language encouraging distribution to all persons served, where applicable.
- Information in the appropriate language if there is a large proportion of non-English speaking persons.

Other information that may be beneficial to include in a public notice, but is not required, includes:

- Geographical extent of the affected area.
  - Where the problem is.
  - Where the problem is NOT.
- Information regarding rehabilitation and recovery efforts.

- Notice that the water utility will keep the public informed through selected mechanisms. (The means by which information will be delivered to consumers should be identified.)

In addition to the above items, public notifications should also consider other potential consumer questions and concerns (e.g., can I water my plants, fill the aquarium, give it to my pets, etc.). Rather than on a printed notification, this information may be disseminated through a consumer hotline set up to answer these types of questions.

For more information regarding risk communication, see US EPA's Risk Communication in Action Case Studies from its Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program (US EPA, 2002b) and CDC's videotape titled "Risk Communication and Bioterrorism" (CDC, 2001b).]

5.3.2 Format

The PN Rule under the SDWA requires that all public notices meet certain standards. These requirements help prevent the notice from being buried in a newspaper and help ensure that consumers can easily read and understand the notice. For notification under the PN Rule, notices must:

- Be displayed in a conspicuous way when printed or posted.
- Not contain overly technical language or very small print.
- Not be formatted in a way that defeats the purpose of the notice.
- Not contain language that nullifies the purpose of the notice.

The drinking water primacy agency may have special formatting requirements. Therefore, the water utility should check with the primacy agency to ensure that all notification format requirements are met.

Suggestions for effective notifications are identified below:

- Assume that consumers only read the top half of the notice (or what can be read in ten seconds). The most important information, especially instructions to protect consumers' health, should be placed on the top half of the notice in large print. Smaller type is appropriate for the less critical elements.
- Try to limit the wordiness of the notice. A question and answer format is easy to read and guides readers to the information that is likely to concern them. Bullets and bold text are also effective.
- Highlight the name of the water utility, especially where people in the area are served by more than one water system. The water utility may also want to prepare a map showing the area served, especially if it extends beyond city limits. The water utility may want to print the notices on its letterhead which, coupled with the title of the notice, will make people immediately recognize the importance of the notice.

Example "boil water," "do not drink," and "do not use" notices are provided in Appendices 9.3.1, 9.3.2, and 9.3.3. An example notice for an unknown contaminant is provided in Appendix 9.3.4. For more guidance on the preparation of notices refer to the "Public Notification Handbook" (US EPA, 2002a).

5.3.3 Notifications for Special Populations

The notification procedures should address the needs of special populations (within the water utility's service area) including but not limited to people with disabilities (e.g., sight, hearing impairment, etc.), non-English speaking residents, individuals who can't read or with low levels of literacy, students, migrant workers, homeless populations, and persons visiting public facilities (e.g., shelters, train stations, playgrounds, parks, etc.). In developing the procedures, the water utility should consider the means by which these population groups and communities access information.

Water utilities should identify ways to target visually and hearing impaired populations and meet their needs. Community centers or targeted word-of-mouth may be useful. Other suggestions can be found in US EPA's "Public Notification Handbook" (US EPA, 2002a).

For notification under the PN Rule, if a large proportion of the population served by the water utility does not speak English, then the water utility must provide at least partially multi-lingual notices. If translations are needed, the water utility notification must, at a minimum, contain information in the appropriate language(s) regarding the importance of the notice, or it must provide a phone number or address where a translated notice or assistance in the appropriate language is available. The drinking water primacy agency for the water utility may have established criteria for what constitutes a large proportion of the people served. If the drinking water primacy agency, or local government, does not determine what constitutes a large proportion of non-English speaking consumers, it may be up to the water utility to make this determination. The water utility should rely on its knowledge of its consumer base or contacts with community representatives. As a guideline in making this determination, some States have used a threshold of ten percent of the population or 1,000 people, whichever is less, for providing multi-lingual information in Consumer Confidence Reports (CCRs).

There are many ways to notify non-English speaking consumers; however, the water utility should establish its own methods and keep them as simple as possible. One way to reach non-English speaking consumers is to establish contacts with local foreign newspapers, foreign television and radio stations, and institutions and people who can translate notices into other languages (e.g., community centers and universities). Targeted word-of-mouth via religious organizations, community leaders, and activist groups is also an effective way to get the notice to non-English speaking consumers, especially if there are no television or radio stations or newspapers in those languages. Posting notices in grocery stores, laundromats, community centers, and other public facilities is also an effective way to get the notice to both non-English speaking populations and other special populations, including migrant workers, homeless populations, and persons visiting public facilities.

Water utilities should remember that some of their customers might have a low reading ability. In this situation, it is important that notices do not contain overly technical or confusing language. For example, a brochure written at an elementary school reading level will need simple explanations of technical information when addressing the general public or a more targeted audience that may have little or no knowledge about the subject matter. Water utility staff responsible for responding to questions about the notice should keep in mind that it might be necessary to read or explain the entire notice to a caller.

5.3.4 Data Visualization and Interpretation Tools

It is possible to use data visualization tools such as icons, maps, graphs, or other visual tools in place of language to convey risk information in public notifications. These visual tools are useful because they tend to transcend cultural boundaries and differing educational levels more easily than language does. For example, a running faucet with a large X over it conveys the message of do not use the water. Thus, more people may understand your message through data visualization than through text. However, use of these tools should be carefully considered because some information may be too complex to present without any language. It may be helpful to use an icon as a background picture in a written notice.

5.4 Methods to Deliver the Public Notification

For a Tier 1 notification under the PN Rule, the water utility must provide notice within 24 hours in a form and manner reasonably calculated to reach all persons served. The form and manner used by the utility are to fit the specific situation, but must be designed to reach residential, transient, and non-transient users of the water system. In order to reach all persons served, water systems are to use, at a minimum, one or more of the following forms of delivery: 1) Appropriate broadcast media (such as radio and television); 2) Posting of the notice in conspicuous locations throughout the area served by the water system; 3) Hand delivery of the notice to persons served by the water system; or 4) Another delivery method approved in writing by the primacy agency. Preferably, the approval of any additional methods of delivery should be done during public health response planning, so the utility is prepared when an actual contamination threat or incident occurs. Examples of other delivery methods include:

- Government access channels
- Web site (local government and others)
- Listserve e-mail
- Newspaper
- Phone banks
- Broadcast phone messages ("reverse 911" messaging)*
- Broadcast faxes
- Mass distribution through community centers (e.g., religious centers, shopping malls, restaurants)
- Door-to-door canvassing
- Town hall meetings
- Regular or special partner conference calls
- Another method approved by the primacy agency in advance or during consultation.

** Note that "reverse 911" messaging may only be effective if the accuracy of the phone numbers in the database are frequently verified.*

The water utility should be sure that all people associated with the response and/or impacted by the event understand the importance of notifying others who may travel through the contaminated area of the distribution system. For instance, people who patronize restaurants or work in office buildings in the distribution area but live elsewhere may not be aware of the water contamination incident unless steps are taken specifically to notify them. For notification under the PN Rule, the utility must

include the following language in its notice: "Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail."

Issues to consider include the population served, population density (i.e., whether the area is rural, urban, or suburban), available assistance, and proximity to and relationship with radio and television stations and newspapers. The methods chosen should reach all persons served by the water system, including residents, employees, and travelers. Also, during a water contamination incident, the area may also experience loss of power, which may affect television communications and potentially newspaper and telephone communications. The water utility should plan alternate delivery methods for such situations.

Any public notification issued should be coordinated with ICS and the Joint Information Center. At the same time, emergency notification of the public and affected businesses needs to be accomplished rapidly and should involve all possible media to be sure of the widest possible distribution. Local radio and television stations as well as web sites should be given the first consideration because of the rapidity with which news can be disseminated by these media. Local newspapers should receive news releases at the same time they are provided to the radio and television facilities; however, actual time of publication of the items will depend on the newspaper's deadline. Notices posted on bulletin boards and the use of sound trucks may provide information quickly to those persons not immediately exposed to other media. Direct notification to customers with special needs (e.g., schools, hospitals, nursing homes, etc.) should be considered. (Customers with special needs are discussed in Section 5.2 of this module.) Recordings describing much of the available up-to-date information may be used on the water utility's telephone system.

In communicating with the media, considerations should be given to establishing protocols for both field and office staff to respectfully defer questions to the personnel identified in the utility's ERP or designated by the Incident Commander. It is essential that the water utility identify **ONE** *information officer* to interface with the media and disseminate public information. Once public health response actions beyond containment are implemented, public health officials may take responsibility for communication with the media. The severity of the emergency may result in the Governor's office taking the lead for communication. The decision on who to assign as spokespersons and whether and when to change spokespersons will be up to the Incident Commander in consultation with State and Federal representatives. Regardless of the agency responsible for incident command, the drinking water utility and public health officials will need to be involved to ensure the accuracy of information being transmitted. Therefore, it is a good idea for the water utility to have a plan in place because they may be called upon to support the *lead agency* in crafting a message for the public. The water utility should be prepared by organizing basic facts about the crisis and its water system; developing key messages to use with the media that are clear, brief, and accurate; and making sure the messages are carefully planned and have been coordinated with local and State officials. Specific details on communicating with the media can be found in Chapter 4 of US EPA's "Public Notification Handbook" (US EPA, 2002a).

Boiler plate news releases aimed at addressing various anticipated events should be prepared in advance to ensure their rapid distribution when a contamination threat or incident occurs. The list of

persons pre-authorized to prepare and release such news items should be layered to ensure that at least one person will always be available and have the authority to issue prompt publication. Preparation of typical press releases as part of planning can save precious hours during an actual emergency and possibly prevent serious health problems resulting from exposure through use of contaminated water. The water utility should explain to the newspaper or station what information it is trying to communicate and why. When a water utility sends a notice to radio and television stations and newspapers, they should write "PRESS RELEASE FOR PUBLIC SAFETY" at the top of the notice to emphasize its importance. Utilities can also have inactive web sites prepared with various informational bulletins that can be quickly activated at the time of an emergency.

The actual delivery of the public notification does not need to be the sole responsibility of the water utility; it can be a coordinated effort with the public health agency, law enforcement, and other agencies. The responsibilities for the delivery of public notification should be identified during public health response planning (discussed in Section 2.1.1 of this module).

6 Short-term Alternate Domestic Water Supply

If the public is asked not to drink or use the water, then provisions for an alternate drinking water supply should be considered. If the water use restrictions are implemented in response to a 'credible' contamination threat, the alternate water supply may be needed only on a short-term basis while efforts are taken to 'confirm' whether or not an incident has occurred. If the restriction is only on consumption (i.e., "do not drink"), then the suspect water can still be used for all other activities that do not involve ingestion of the water. In this situation, it will only be necessary to provide an alternate drinking water supply for consumption and related activities such as food preparation. A "do not use" notice is much more restrictive and may adversely impact public sanitation. Because water use restrictions will generally be of short duration while steps are taken to confirm the incident and identify the contaminant, they should not significantly impact firefighting. Strategies for short-term provision of an alternate water supply are presented in this section. Such strategies may be different from those used for a long-term alternate water supply that may be necessary during remediation and recovery (see Module 6, Section 5).

6.1 Alternate Supply for Consumer Use

The water utility will need to identify options for the provision of an alternate water supply for consumer use during public health response planning. To the greatest degree possible, plans for the provision of an alternate water supply should not rely on Federal and/or State support. During the planning stage, the utility and public health departments should:

- Identify agencies, companies, contractors, surrounding communities, and related utilities that could assist in providing alternate water supplies in the event of a water contamination incident.
- Establish *mutual aid agreements* with companies, contractors, surrounding communities, and related utilities, as appropriate.
- Maintain phone numbers for points of contact for entities that could assist in providing alternate water supplies.
- Advise consumers to maintain an emergency supply of water such as bottled water.
- Identify optimal locations for parking water tankers and distributing bottled water. Having a well-thought out plan regarding optimal locations for positioning these water supplies could greatly benefit the community.
- Identify ways to use only uncontaminated water sources if multiple contributing water sources are available.

Possible alternate water supply options, as previously listed in Table 5-2, include (but are not limited to) the following:

Table 5-6. Options for Short-term Alternate Supplies of Drinking Water

Type	Source
Bottled water	Local government agencies
	Local retailers
Bulk water	Certified water haulers
	Military assets (i.e., National Guard)
	Neighboring water utilities
Utility treated	Uncontaminated source water
	Uncontaminated water stored in the distribution system

The following is a list of entities that the utility and public health departments should consider contacting to assist in providing alternate water supplies in the event of a water contamination incident.

- Local businesses such as dairies, well drillers, or distributors may have tank trucks that can be made suitable for carrying water.
- Some companies may have equipment such as chlorinators or generators that can be used for emergency disinfection.
- Irrigation supply companies may have pipe that can be used to extend water supply lines.
- Other water utilities in the area may have spare parts (valves, pumps, pipe) available for use in an emergency and may be able to supply personnel to assist during emergencies.
- Bottle manufacturers may be able to provide milk jugs, cubitainers, and other types of plastic bottles that can be used to transport the water to the affected community. Providing bottles would avoid the potential public health problems associated with the public using contaminated containers to collect and haul drinking water from distribution sites.
- Hospitals and universities may maintain backup water supplies for consumption.
- Farms may maintain water supplies for livestock and agriculture.
- Local industries may maintain backup water supplies for industrial processes.
- Some local citizens and businesses may have well water sources that can be utilized.
- Local authorities may permit the utility to pump and treat an available surface water source.

Some of the sources listed above may not necessarily be connected to the public water system or may not be connectable due to regulatory restraints. The inclusion of a potential source of backup water in this list should not be interpreted as permission to use them.

6.1.1 Who Provides the Alternate Water

The water utility and local authorities may or may not have the resources to provide an alternate short-term water supply. In the event that resources are not adequate, the water utility may call upon State and Federal authorities for assistance. The USACE is authorized to provide clean drinking water to communities in cases where the existing drinking water supply is compromised or otherwise unavailable. FEMA, under the Disaster Relief Act Amendments of 1974, will provide various services including relief efforts during an emergency. Other Federal agencies such as US EPA may also provide assistance. Additional detail regarding responsibility of Federal agencies for the distribution of drinking water during an emergency is presented in Module 1, Appendix 6.2.

6.1.2 Potential Household Sources of Emergency Water Supply

In conjunction with providing an alternate water supply, the water utility should consider a public awareness program providing guidance to consumers on finding alternate water supply sources around the home, purifying water, and maintaining an emergency supply of water. This information could be included in pamphlet form along with the utility bill or with the CCR. Table 5-7, 5-8, and 5-9 contain information from FEMA that could be provided to the public **after** the decision has been made regarding the type of notice to post (FEMA, 2003c). This information can be provided to aid the public in meeting the restrictions of any "boil water," "do not drink," or "do not use" notices. Any notice to the public should include only the options listed in the following tables that are appropriate for the particular situation. For example, most of the purification techniques are only appropriate for biological contamination and would not be provided to consumers in the case of chemical or radiological contamination.

Table 5-7. Alternate Water Sources in the Home

Any of the listed sources may contain contaminated water if filled in the timeframe of the contamination incident.

- Ice cubes
- Chilled water stored in the refrigerator
- Hot water tank – Turn off the power and let the tank cool. Place a container underneath and open the drain valve at the bottom of the tank. Do not turn the tank on again until water services are restored.
- Toilet tank – The water in the tank (**not the bowl**) is safe to drink unless chemical treatments have been added to the tank water, such as drop-in cleaners.
- Water pipes – Release air pressure into the plumbing system by turning on the highest faucet in the house; then drain the water from the lowest faucet.
- Rain water, spring water, and water from streams, ponds, rivers, lakes, and garden hoses – ***Purify these water sources before use.***

Caution: Avoid water from waterbeds as a source for drinking water. Pesticidal chemicals are in the plastic casing of the bed and chemicals have probably been added to the water to prevent the growth of algae, fungi, and bacteria. The water is safe only for hand washing and laundering.

Table 5-8. Public Guidance on Water Purification

- ***Water that local officials report has been contaminated with toxic chemicals or radioactive materials should not be purified using home decontamination methods.*** Although some home decontamination methods may be able to remove toxic chemicals or radioactive material, they should not be relied upon as the sole means of decontamination because it may not be possible to determine the effectiveness of these devices (i.e., adsorptive material that might remove chemicals could have been saturated during previous use and may not remove the contaminant of immediate concern).
- **Straining.** Water containing sediment or floating material should be strained through a cloth or paper filter as the first step in the purification process. Some cloth and paper filters work better than others; practice is required to use this technique to remove sediment and floating material.
- **Boiling.** (See Section 5.4.1).
- **Chemical sterilization (chlorine bleach).** In some situations, boiling may not be an option. The alternative is to treat the water chemically. Plain household chlorine bleach may be used. Be sure the label states that hypochlorite is the only active ingredient. Bleaches containing soap or fragrances are not acceptable. With an eyedropper, add 8 drops of bleach per gallon of water (16 drops if the water is cloudy), stir, and let stand. After 30 minutes, the water should taste and smell of chlorine. At this point, it can be used. If the taste and smell (and appearance in the case of cloudy water) has not changed, add another dose and let stand. If after one half hour the water does not have a chlorine smell, do not use it. Chlorine bleach has a finite shelf life and tends to lose its effectiveness over time. This may require that larger quantities be used than the ones specified. It is advisable to check the expiration date and to periodically refresh your supply.
- **Chemical sterilization (iodine).** Disinfection with iodine is an alternative method of water treatment when it is not feasible to boil water. Two well-tested methods for disinfection with iodine are the use of tincture of iodine and tetraglycine hydroperiodide tablets (e.g., Globaline, Potable-Aqua, or Coghlan's). Tincture of iodine (2%) can commonly be found in medicine chests or first-aid kits. The recommended doses are 5 drops for clear water or 10 drops for cloudy water. Water should then stand for a minimum of 30 minutes before it is safe to use. Very turbid or cold water can require prolonged contact time; if possible, such water should be allowed to stand several hours before use. To ensure that *Cryptosporidium* is killed, water would need tp stand for 15 hours before drinking. The tetraglycine hydroperiodide tablets are available from pharmacies and sporting goods stores. Users should follow the manufacturers' instructions. If water is cloudy, the number of tablets used should be doubled; if water is extremely cold (<5 °C; <41 °F), an attempt should be made to warm the water, and the recommended contact time should be increased to achieve reliable disinfection.
- **Filtration devices**, such as those used for camping and backpacking, may also be used to purify water from natural sources (e.g., lakes and streams) provided that these devices are rated as "purification systems," which means they can remove viruses.

Caution: Any water that is obtained from sources outside the home or water that does not appear clear should be sterilized. Non-sterilized water may be contaminated with various harmful microorganisms.

Table 5-9. Public Guidance on Water Storage

- Store the water in a clean and sanitary glass or plastic container. Opaque plastic containers are good because they are lightweight, sturdy, and limit the entry of light, which can shorten the shelf life of the water. Metal containers should be considered as a last resort because they may corrode and give water an unpleasant taste. ***Caution:*** Do not use pesticide containers to store water.
- Store 1 to 2 gallons per person per day for drinking and 1 to 2 gallons per person per day for basic sanitation (e.g., brushing teeth and washing hands). Consumers with infants and young children, nursing mothers, and people who are ill will want to store additional water.
- Store containers in a cool, dry place away from direct sunlight.
- Store plastic container away from heat and light to prevent leakage.
- Store water in plastic containers away from gasoline, kerosene, pesticides or similar substances because vapors from these products can penetrate plastic and contaminate the water.
- Make sure the shelf or storage area is strong enough to support the weight of the water (over 8 pounds per gallon).
- Replace stored water every six months to maintain quality. For commercially bottled distilled or drinking water, check the label for an expiration date. If none is given, the shelf life of commercially bottled water is unknown and a conservative six-month replacement practice should be followed.
- Water can also be stored in a freezer. In the case of a power outage, the frozen water provides the added benefit of keeping foods frozen until power is restored. Leave 2 to 3 inches of air space in the top of containers before freezing to prevent the container from bursting as water expands during freezing. Some thin-walled glass containers may break regardless of the air space provided. Water stored in the freezer should be replaced periodically to avoid its accumulation of tastes and odors from the food stored with the ice.
- If you are on a municipal water supply, the water you are currently using for drinking and cooking should also be suitable for storing for emergencies. While you can expect that water from a public water supply will be safe, remember that the container used to collect and store the water should also be clean in order to maintain the quality of the stored water.

6.2 Alternate Supply for Firefighting Needs

A "do not use" notice will have implications with respect to water used for firefighting. Because firefighting does not generally involve direct contact with the water, it may be possible to use the contaminated water for this purpose; however, certain contaminants may pose a hazard even during firefighting activities. For instance, if a disinfection resistant pathogen that poses a health risk via inhalation were suspected as the contaminant, use of the water for firefighting could expose firefighters and the public to aerosol release and possible inhalation or dermal exposure to these harmful microorganisms. Thus, in this case, it may be necessary to identify an alternate supply of water for firefighting.

In deciding whether or not to permit use of the contaminated water for the purpose of firefighting, the decision officials (i.e., public health, utility, fire chief, local government, etc.) will need to consider the following:

- Whether the contaminant will be spread by use of the water during firefighting.
- Whether the contaminant will pose a greater or more adverse/severe threat than the threat posed by lack of water for firefighting.
- Whether the contaminant will pose a threat to firefighters.
- Whether the contaminant will have an adverse environmental impact if used for firefighting.

If public health officials determine that the contaminant does not pose an inhalation or dermal exposure threat, the Incident Commander, in conjunction with local officials, may choose to permit use of the water for fire protection. However, if a readily available alternate supply of water for firefighting does exist, it may be preferable to use this source in any case in order to eliminate any possibility of exposure via firefighting as well as to allay public concern. Note that firefighters may wear protective suits and/or respirators that may provide some level of protection from some contaminants. In any event, the fire chief should always be involved in deciding whether or not to use contaminated water.

If the contaminant is determined to pose a significant risk during firefighting, an alternate source of water for firefighting would need to be secured. As part of public health response planning and emergency response preparations, water utilities should make agreements with surrounding communities to utilize their water sources for firefighting purposes. During an emergency, pumper trucks could be filled at the community water source and kept at the fire department for firefighting purposes. State offices of emergency services may assist with the acquisition of bulk water trucks from unaffected areas within the State for firefighting purposes. Planning with these State offices is critical to determine the types of resources available and the procedures to acquire them. Federal agencies such as the USACE, FEMA, and the US Forest Service may be able to provide firefighting equipment and water for firefighting purposes. Under the NRP Emergency Support Function (ESF) #4, Firefighting Annex, the US Forest Service serves as the primary agency for firefighting support. Responsibilities under ESF #4 include detection and suppression of wildland, rural, and urban fires resulting from, or occurring coincidentally with, a major disaster or emergency requiring Federal response assistance. ESF #4 manages and coordinates fire-fighting activities, including the detection and suppression of fires on Federal lands, and provides personnel, equipment, and supplies in support of State and local agencies involved in rural and urban firefighting operations (FEMA, 2003b).

The reality is that it may take some time to mobilize alternate water supplies for firefighting; therefore, in that short time period, the contaminated water may need to be used for the purpose of firefighting.

7 Returning to Normal Operation and Use

Following the issuance of a public notification in response to a credible contamination threat or confirmed incident, it will be necessary to notify the public once the situation has been resolved and the appropriate officials have determined that it is safe to resume normal use of the public drinking water supply. The same communication methods discussed in Section 5.4 of this module (e.g., posting or hand-delivery of public notices, broadcast media, web sites, etc.) for notifying the public of use restrictions can be used to efficiently inform the public that normal use of the water can be resumed. In addition, it will be necessary to demobilize any alternate water supplies that have been implemented. The following two examples illustrate when this type of situation might occur:

Example #1: A "do not use" notice was issued in response to a 'credible' contamination threat to the drinking water supply. The following day, results from laboratory analysis of samples collected throughout the distribution system became available. The Incident Commander, along with officials from the utility, public health department, and drinking water primacy agency reviewed this data, along with additional new information, and concluded that the water had **not** been contaminated. The public was notified, through a variety of vehicles such as broadcast media, that it was safe to resume normal use of the water. A press conference was held that evening to provide more detailed information regarding the steps that were taken to ensure that the water was safe and to explain the rational for issuing the "do not use" notice to begin with.

Example #2: A "do not drink" notice was issued to consumers of the entire distribution system in conjunction with implementation of a containment strategy in response to a 'credible' contamination threat. The distribution system was extensively sampled both within and outside of the contained area. Twenty-four hours later, analytical results were available that identified trace amounts of a contaminant within the contained area of the system, while all results from the rest of the system were below the detection limit for the same contaminant. Based on this information, the Incident Commander, in conjunction with officials from other organizations, determined that the containment strategy was successful. The public was notified through the use of broadcast media that they could resume normal use of the water outside of the contained area. Since there were only a few dozen residents, and no businesses, within the contained area, each resident was directly contacted and instructed to continue use of only bottled water for drinking and cooking. During a press conference that evening, officials provided more detail regarding the contaminant, the steps taken to isolate the contaminated water, and ongoing sampling throughout the system to verify that the contaminant had not spread beyond the contained area.

Returning to normal operations after treatment and rehabilitation of a contaminated water supply is addressed in Module 6, Sections 5.5 and 7.3.3.

8 References and Resources

References and information cited or used to develop this module are listed below. The URLs of several sources are cited throughout the text. These URLs were correct at the time of the preparation of this document. If the document is no longer available at the URL provided, please search the sponsoring organization's Web site or the World Wide Web for alternate sources. A copy of referenced documents may also be provided on the upcoming CD version of this module, although readers should consult the referenced URL for the latest version.

AdvanticaStoner. 2003. "SynerGEE Water" http://www.advantica.biz/stoner_software/synergee_water/

AWWA. 2002. Protecting Our Water: Drinking Water Security in America After 9/11. Denver, CO.

ATSDR. 2004. "Home" http://www.atsdr.cdc.gov

ATSDR. 1997a. "ToxFAQs™ for Cyanide" http://www.atsdr.cdc.gov/tfacts8.html

ATSDR. 1997b. "Toxicological Profile for Ethylene Glycol and Propylene Glycol" http://www.atsdr.cdc.gov/toxprofiles/tp96.html

CDC. 2004. "Emergency Preparedness and Response" http://www.bt.cdc.gov

CDC. 2001a. The Public Health Response to Biological and Chemical Terrorism: Interim Planning Guidance for State Public Health Officials. Atlanta, GA. http://www.bt.cdc.gov/Documents/Planning/PlanningGuidance.pdf

CDC. 2001b. "Risk Communication and Bioterrorism" http://www.phppo.cdc.gov/PHTN/1206FactSheet.pdf

CDC. 2001c. "Registry of Toxic Effects of Chemical Substances (RTECS)" http://www.cdc.gov/niosh/rtecs.html

FEMA. 2003a. "Emergency Personnel" http://www.fema.gov/tabs_emergency.shtm

FEMA. 2003b. "Federal Response Plan" http://www.fema.gov/rrr/frp

FEMA. 2003c. "Locating Safe Drinking Water" http://www.fema.gov/rrr/waterf.shtm

FEMA. 2003d. "Mobile Operations Capability Guide for Emergency Managers and Planners" http://www.fema.gov/rrr/mers01.shtm

Haestad Methods. 2004. "WaterCAD ™ " http://www.haestad.com/water/default.asp

KYpipe. "PIPE2000" http://www.kypipe.com

Meinhardt, Patricia L. MD, MPH, MA. 2002. "Recognizing Waterborne Disease and the Health Effects of Water Pollution: A Physician On-line Reference Guide." http://www.waterhealthconnection.org

Meinhardt, Patricia L. MD, MPH, MA. 2002. "Physician Preparedness for Acts of Water Terrorism." http://www.waterhealthconnection.org/bt/index.asp

USAMRIID. 2001. "Medical Management of Biological Casualties Handbook Fourth Edition" http://www.usamriid.army.mil/education/bluebook.html.

MWH Soft, Inc. 2004. "H_2ONET" http://www.mpact.com/page/p_product/net/net_overview.htm

Science Applications International Corporation. 2003. "PipelineNet" http://eh2o.saic.com/iwqss/

US DHS. 2004. "National Response Plan, Draft #1"

US DOE. 2003. "Risk Assessment Information System" http://risk.lsd.ornl.gov/index.shtml

US EPA. In prep. Water Contaminant Information Tool. Office of Water.

US EPA. 2004. "List of Drinking Water Contaminants & MCLs" http://www.epa.gov/safewater/mcl.html#mcls

US EPA. 2004a. Small and Medium Water System Emergency Response Plan Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002. EPA/816/R-04/002. Office of Water.

US EPA. 2003. Large Water System Emergency Response Plan Outline: Guidance to Assist Community Water Systems in Complying with the Public Health Security and Bioterrorism Preparedness and Response Act of 2002. Office of Water.

US EPA. 2002a. Public Notification Handbook. EPA/816/R-00/010. Washington DC. http://www.epa.gov/safewater/pws/pn/handbook.pdf

US EPA. 2002b. Risk Communication in Action: Environmental Case Studies. EPA/625/R-02/011. Cincinnati, OH. http://www.epa.gov/ordntrnt/ORD/NRMRL/Pubs/625R02011/625R02011.html

WHO. 2003a. "Search" http://www.who.int/search/en/.

WHO. 2003b. "Public health response to biological and chemical weapons: WHO Guidance, 2nd edition (Draft, May 2003)" http://www.who.int/csr/delibepidemics/biochemguide/en/index.html

9 Appendices

9.1 Contaminant Characterization and Transport Worksheet

INSTRUCTIONS
The purpose of this worksheet is to help organize information that will lead to the identification of the contaminant to facilitate decisions on appropriate operational responses and provide more accurate information for public communication/notification. Contaminant identification will most likely first be a presumptive identification followed by more lengthy procedures to verify the identity of the contaminant. While validated analytical results are typically the most reliable means of contaminant identification, other information collected during the ***threat evaluation*** *and* ***site characterization*** *may provide valuable insight regarding the identity of the contaminant.*

SITE CHARACTERIZATION/THREAT EVALUATION SUMMARY

Describe the contaminant's odor, if applicable. _____

Describe the *reported* taste of the contaminant, if applicable. _____
Caution: Do NOT taste the water.

What was the physical form of the contaminant?

☐ Solid	☐ Liquid	☐ Gas
☐ Slurry	☐ Powder	☐ Granules

☐ Other _____

What color was the contaminant? _____

Summarize additional information obtained during site characterization/threat warning that is relevant to contaminant identification. _____
_____
_____
_____

Summarize the on-line monitoring data, consumer complaints, or witness accounts that are relevant to contaminant identification. _____
_____
_____
_____

Field Analysis Summary

Summarize the results of the field analysis for the following parameters:

Radiation _____
Chlorine residual _____
pH, conductivity _____
Cyanide _____
Volatile chemicals _____
Chemical weapons _____
Biotoxins _____
Pathogens _____
Other _____

Public Health Information

Have death or disease in the population been reported? ☐ Yes ☐ No ☐ Unknown

Type/symptoms _____
Is there information on unusual sales of pharmaceutical supplies (e.g., diarrhea medication)?_____
Number of people affected _____
Number of fatalities _____
Location/area affected _____

Was an epidemiological investigation conducted? ☐ Yes ☐ No ☐ Unknown
Results _____

Was a clinical investigation conducted? ☐ Yes ☐ No ☐ Unknown
Results _____

Is the contaminant acutely toxic and what are the acute effects? ☐ Yes ☐ No ☐ Unknown
Describe _____

LABORATORY ANALYSIS SUMMARY

Results of analysis _____

Reporting units _____

Analytical method _____

Minimum reporting level _____

Precision (relative standard deviation) _____

QA/QC (e.g., recovery of matrix spikes, standard checks, etc.) _____

Summarize additional information obtained during laboratory analysis that is relevant to contaminant identification.

_____
_____
_____

CONTAMINANT CHARACTERISTICS

What is the class of the contaminant?
☐ Biological ☐ Chemical ☐ Radiological
☐ Unknown _____

Can any conclusions regarding the contaminant properties be made? (Place an 'X' in the appropriate column)

	Yes	No	Unknown	Comment/Additional Information
Is the contaminant susceptible to disinfection or chemical oxidation?				
Does the contaminant hydrolyze into less toxic products?				
Does the contaminant hydrolyze into more toxic products?				

Does the contaminant react at certain pHs?				
Is the contaminant water soluble?				
Does the contaminant have a discernable taste, odor, or color?				
Is the contaminant volatile or semi-volatile?				
Does the contaminant impact the pH?				
Does the contaminant impact conductivity?				
Does the contaminant impact other water quality parameters?				
Does the contaminant react with certain disinfectants (i.e., chlorine, chloramines, etc.)?				
What is the contaminant's half life?				

Contaminant Public Health Effect Information

What are the primary routes of exposure?
☐ Ingestion ☐ Inhalation ☐ Dermal Contact
☐ Unknown _____

What are the acute health effects for the exposure routes identified? _____
_____
_____

What is the contaminant's LD_{50}/ID_{50}? _____
_____
_____

What is the length of time to first onset of symptoms after exposure? _____
_____
_____

What are the chronic health effects associated with exposure to the contaminant? _____
_____
_____

Does the contaminant have a method of secondary transmission?
☐ Yes ☐ No ☐ Unknown
Describe _____

Is an approach available to prevent undesirable health effects from the contaminant?
☐ Yes ☐ No ☐ Unknown
Describe _____

Are there treatments available for individuals exposed to the contaminant?
☐ Yes ☐ No ☐ Unknown
Describe _____

Are health standards for the contaminant available?
☐ Yes ☐ No ☐ Unknown
Describe _____

By which exposure route(s)?
☐ Ingestion ☐ Inhalation
☐ Dermal ☐ Ocular

List the levels for each exposure route.

_____

_____

Contaminant Treatment Information

Treatment Types	Could be used to treat the contaminant?	Degradation products formed as a consequence of treatment	Rating of effectiveness (poor, fair, good) of percent effectiveness
Lime softening	☐ Yes ☐ No		
Reverse osmosis	☐ Yes ☐ No		
Standard chlorination	☐ Yes ☐ No		
Enhanced chlorination	☐ Yes ☐ No		
Standard filtration	☐ Yes ☐ No		
Enhanced filtration	☐ Yes ☐ No		
Membrane filtration	☐ Yes ☐ No		
Nanofiltration	☐ Yes ☐ No		
Electrodialysis	☐ Yes ☐ No		
Cation exchange resin	☐ Yes ☐ No		
Anion exchange resin	☐ Yes ☐ No		
Activated alumina	☐ Yes ☐ No		
Chloramine	☐ Yes ☐ No		
Chlorine dioxide	☐ Yes ☐ No		
Standard UV	☐ Yes ☐ No		
Enhanced UV	☐ Yes ☐ No		
Standard ozone	☐ Yes ☐ No		
Enhanced ozone	☐ Yes ☐ No		
Standard GAC	☐ Yes ☐ No		
Enhanced GAC	☐ Yes ☐ No		
Standard air stripping	☐ Yes ☐ No		
Enhanced air stripping	☐ Yes ☐ No		
Other Methods	☐ Yes ☐ No		

Access to contaminant information (effects and properties)

In-house information
Contact/phone no. _____
Internal database _____

Public Health officials
Contact/phone no. _____
Web site/database _____

US EPA Water Contaminant Information Tool
Web site/access code_____

Resources

- US EPA water contaminant information tool (WCIT), which is being developed specifically for the water sector and is described in Appendix 8.9 of Module 2.
- US EPA's List of Drinking Water Contaminants & MCLs: http://www.epa.gov/safewater/mcl.html#mcls.
- Agency for Toxic Substances and Disease Registry (ATSDR): www.atsdr.cdc.gov.
- CDC Emergency Preparedness and Response: www.bt.cdc.gov.
- Recognizing Waterborne Disease and the Health Effects of Water Pollution: A Physician On-line Reference Guide: www.WaterHealthConnection.org.
- Physician Preparedness for Acts of Water Terrorism: www.waterhealthconnection.org/bt/index.asp.
- Registry of Toxic Effects of Chemical Substances (RTECS): www.cdc.gov/niosh/rtecs.html.
- Risk Assessment Information System (RAIS), which contains information taken from US EPA's Integrated Risk Information System (IRIS), the *Health Effects Assessment Summary Tables* (HEAST-rad HEAST-nonrad), US EPA Peer Reviewed Toxicity Values (PRTVs) Database, and other information sources: http://risk.lsd.ornl.gov/index.shtml.
- United States Army Medical Research Institute of Infectious Diseases (USAMRIID) Medical Management of Biological Casualties Handbook: http://www.usamriid.army.mil/education/bluebook.html.
- WHO: www.who.int/search/en/.
- WHO's "Public health response to biological and chemical weapons:" www.who.int/csr/delibepidemics/biochemguide/en/index.html.

CONTAMINANT TRANSPORT

Summarize what is known regarding the location of contaminant introduction.

_____
_____
_____

How much material was used _____(lbs., tons, gal, etc.)

How was it added? ☐ Single dose ☐ Over time ☐ Unknown

Time period of suspected contaminant introduction. _____

Elapsed time. _____

Method of estimating the spread.
☐ Manual calculations ☐ Hydraulic model ☐ Water flow analysis
☐ GIS ☐ Field analysis ☐ Areas of customer complaints
☐ Areas of people with health-related symptoms
☐ Other _____

Estimate the contaminated area. _____

Estimate the population affected._____

Identify any customers with special needs that are within the affected area.
☐ Critical Care Facilities
☐ Hospitals ☐ Clinics
☐ Nursing Homes ☐ Dialysis Centers
☐ Other _____

- ☐ Schools
- ☐ Day Care Facilities
- ☐ Businesses
  - ☐ Food and Beverage Manufacturers
  - ☐ Restaurants
  - ☐ Power Generation Facilities
  - ☐ Other _____
  - ☐ Commercial Ice Manufacturers
  - ☐ Agricultural Operations

SIGNOFF

Name of person completing form

Print name _____

Signature _____ Date/Time: _____

9.2 Public Health Response Action Worksheet

INSTRUCTIONS

The purpose of this form is to help organize information to aid in the evaluation of containment and public notification options. The objectives of public health response actions (operational and public notification) are to prevent or limit public exposure to potentially contaminated water by either restricting further propagation of the contaminant through the distribution system or restricting use of the water through public notification. This worksheet assumes that the "Contaminant Characterization and Propagation Worksheet" in Appendix 9.1 has been completed to the extent possible.

ASSESSMENT OF PUBLIC HEALTH IMPACT

Identity of the contaminant ☐ Suspected ☐ Known ☐ Unknown

Describe _____

Contaminant properties (if known):

Toxic or infectious dose (LD_{50}/ID_{50}): _____

Route of exposure:

☐ Ingestion ☐ Inhalation ☐ Dermal Contact

☐ Other _____

Symptoms of exposure to high dose: _____

Symptoms of exposure to low dose: _____

Other: _____

EVALUATION OF CONTAINMENT OPTIONS

Describe the location and extent of the contaminated area. _____

_____

_____

Containment options

☐ Valve closures ☐ Reverse flow conditions ☐ By-pass

☐ Isolate zone(s)

☐ Other _____

Critical equipment within contaminated area

☐ System equipment ☐ Zones ☐ Pump stations

☐ Hydrants

☐ Other _____

Customers with special needs within contaminated area

☐ Critical Care Facilities

- ☐ Hospitals ☐ Clinics
- ☐ Nursing Homes ☐ Dialysis Centers
- ☐ Other _____

☐ Schools

☐ Day Care Facilities

☐ Businesses

- ☐ Food and Beverage Manufacturers ☐ Commercial Ice Manufacturers ☐ Restaurants ☐ Agricultural Operations
- ☐ Power Generation Facilities
- ☐ Other _____

Effectiveness of containment options

☐ Complete contaminant isolation ☐ Reduction in spread of contaminant
☐ Unknown
☐ Other _____

Is containment expected to provide adequate public health protection?
☐ Yes ☐ No ☐ Unknown

Timeline for implementation of containment options

Containment procedures to begin: _____
Containment procedures to end: _____

EVALUATION OF PUBLIC NOTIFICATION OPTIONS

Is public notification necessary? ☐ Yes ☐ No

Collaboration Agencies (identified in Public Health Response Plan and Utility's ERP)

☐ Public health agencies ☐ Police departments ☐ Fire departments
☐ Hospitals/clinics ☐ Laboratories ☐ Drinking water primacy agency
☐ Regional Poison Control Center
☐ Other _____

Type of notification (Follow steps shown)

Is the contaminant known? ☐ Yes ☐ No
If no, issue a " Do Not Use" notice.

- If yes, is boiling effective and advisable? ☐ Yes ☐ No ☐ Unknown
If yes, issue a "Boil Water" notice.

- If no, is there a risk of dermal or inhalation exposure? ☐ Yes ☐ No ☐ Unknown
If no, issue a "Do Not Drink" notice.
If yes/unknown, issue a " Do Not Use" notice.

Content of public notification

☐ Has the contamination incident been confirmed? ☐ Yes ☐ No
☐ Is the contaminant known? ☐ Yes ☐ No
☐ If yes, identity of the contaminant _____
☐ Characteristics of the contaminant _____
☐ Restrictions on use _____
☐ Ingestion exposure ☐ Inhalation exposure ☐ Dermal exposure
☐ Exposure symptoms _____
☐ Medical treatments _____
☐ Transmission mode (if biological) _____
☐ Duration of restriction _____
☐ Alternate water supply _____
☐ Additional instructions to consumers _____
☐ Other information about the incident _____
☐ Other _____

Notification to customers with special needs

- ☐ Critical Care Facilities
  - ☐ Hospitals
  - ☐ Clinics
  - ☐ Nursing Homes
  - ☐ Dialysis Centers
  - ☐ Other _____
- ☐ Schools
- ☐ Day Care Facilities
- ☐ Businesses
  - ☐ Food and Beverage Manufacturers
  - ☐ Commercial Ice Manufacturers
  - ☐ Restaurants
  - ☐ Agricultural Operations
  - ☐ Power Generation Facilities
  - ☐ Other _____

Are there subpopulations that will be affected at a greater rate than general population?
☐ Yes ☐ No ☐ Unknown
Describe _____

Notification to consecutive system.
☐ Yes ☐ No ☐ Not Applicable

Method of dissemination (check all that apply)

- ☐ Broadcast media (radio and television)
- ☐ Government access channels
- ☐ Web site
- ☐ Listserve email
- ☐ Newspaper
- ☐ Letters by mail
- ☐ Newsletters (water utility/partner organizations)
- ☐ Phone banks
- ☐ Broadcast phone messages
- ☐ Broadcast faxes
- ☐ Posting in conspicuous locations
- ☐ Mass distribution through partners
- ☐ Hand delivery
- ☐ Door-to-door canvassing
- ☐ Town hall meetings
- ☐ Conference calls
- ☐ Other _____

Notification/restriction timeline

Notification/restriction to begin: _____
Notification/restriction to end: _____

ALTERNATE WATER SUPPLY NEEDS

Is an alternate water supply needed?

- ☐ Drinking water
- ☐ Firefighting
- ☐ Other _____

Where can customers obtain the alternate water supply?

- ☐ Bottled water provided by local government agencies
- ☐ Bottled water provided by local retailers
- ☐ Bulk water provided by certified water haulers
- ☐ Bulk water transported or provided by military assets
- ☐ Bulk water providing by neighboring water utilities
- ☐ Water treated at plant and hauled to distribution centers (i.e., in the case of distribution system contamination)
- ☐ Other _____

What customers with special needs should be notified of the alternate water supply availability?

- ☐ Critical Care Facilities
  - ☐ Hospitals
  - ☐ Clinics
  - ☐ Nursing Homes
  - ☐ Dialysis Centers
  - ☐ Other _____
- ☐ Schools
- ☐ Day Care Facilities
- ☐ Businesses
  - ☐ Food and Beverage Manufacturers
  - ☐ Commercial Ice Manufacturers
  - ☐ Restaurants
  - ☐ Agricultural Operations
  - ☐ Power Generation Facilities
  - ☐ Other _____

SIGNOFF

Name of person completing form

Print name _____

Signature _____ Date/Time: _____

9.3 Example Notifications

The subsections that follow contain examples of notices, as listed below.

9.3.1 Example Boil Water Notice
9.3.2 Example Do Not Drink Notice
9.3.3 Example Do Not Use Notice
8.3.4 Example Notice for an Unknown Contaminant

The contaminant (E. coli) used in the example in Appendix 9.3.1 has mandatory language on health effects, which must be included exactly as written according to 40 CFR 141.205(d). This mandatory language is presented in *italics*.

All notices must also contain the following italicized language, where applicable [40 CFR 141.205(d)].

> *Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.*

Information in brackets in each example is to be filled in with specific details relevant to the situation.

9.3.1 Example Boil Water Notice

WARNING

BOIL YOUR WATER BEFORE USING

[The Holly County Water System] water is contaminated with [fecal coliform/E. coli]

[Fecal coliform or E. coli] bacteria were found in the water supply on [November 5th]. These bacteria can make you sick and are of particular concern for people with weakened immune systems.

What are Fecal Coliforms and E. Coli?

- *Fecal coliform and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes.*

What should I do?

- DO NOT DRINK THE WATER WITHOUT BOILING IT FIRST OR USE BOTTLED WATER. Bring all water to a boil, let it boil for [three minutes], and let it cool before using. Boiled or bottled water should be used for drinking, making ice, brushing teeth, washing dishes, and preparing food until further notice. Boiling kills bacteria and other organisms in the water.

What are the symptoms of illness caused by these organisms?

- *Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems.*

- The symptoms above are not caused only by organisms in drinking water. If you experience any of these symptoms and they persist, you may want to seek medical advice. People at increased risk should seek advice about drinking water from their health care providers.

What happened? What is being done?

The water distribution system was contaminated with fecal coliform. We are working with law enforcement and the public health department to investigate/resolve this issue. We are currently increasing the chlorination levels at the treatment plant as well as at other locations throughout the system. Therefore, your water may have a stronger chlorine smell than usual. In addition, we are evaluating all available information and conducting tests to confirm the extent of the contamination of the system. We will inform you when tests show no bacteria and you no longer need to boil your water. We anticipate resolving the problem within the next 48 hours.

Who do I contact for more information?

For more information, please contact [Joseph Smith] at [555-555-6789]. General guidelines on ways to lessen the risk of infection by microbes are available from the US EPA Safe Drinking Water Hotline at 1-800-426-4794, Poison Control at 1-800-222-1222, and [the Public Health Department Hotline at 1-800-123-4567].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand.

This notice is being sent to you by [Holly County Water System]. State Water System ID# [10001]. Date distributed: [November 6, 2003]

9.3.2 Example Do Not Drink Notice

WARNING

DO NOT DRINK THE WATER

[Paraquat] found in the [City of Rolling Brook] water supply on [October 10th]

Bottled water can be obtained at [Islington Station High School and Penn Road High School 24 hours per day].

What is Paraquat?
Paraquat is a chemical usually used to kill weeds. This chemical can make you sick and may result in death.

What should I do?

- DO NOT DRINK THE WATER. Do ***not*** use the water for drinking, making ice, brushing teeth, washing dishes, or preparing food until further notice.

What are the symptoms of illnesses associated with paraquat poisoning?

- Symptoms associated with exposure to paraquat include abdominal pain, nausea, vomiting, hematemesis, diarrhea, convulsions, lethargy to coma, and death.
- If you or someone you know exhibits any of these symptoms, immediately contact your health care provider. In addition, please notify [the public health department at 1-800-123-4567].

What happened? What is being done?
On October 10th, the water distribution system was contaminated with paraquat. We are working with law enforcement and the public health department to investigate/resolve this issue. We have tested the water in various parts of the distribution system to verify the extent of the paraquat contamination. Based on these tests, we have isolated the portion of the system located north of Aspen Street and east of River Road. Everyone in this portion of the system **should not drink the water**. We have implemented additional security procedures to protect the system against further contamination. Additional information will be provided 24 hours/day on Channel 57- the local government television channel.

Who do I contact for more information?
For more information, please contact [Joseph Smith] at [555-555-6789]. Additional information is available from the US EPA Safe Drinking Water Hotline at 1-800-426-4794, Poison Control at 1-800-222-1222, and [the Public Health Department Hotline at 1-800-123-4567].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand.

This notice is being sent to you by [City of Rolling Brook Water System]. State Water System ID#[50005]. Date distributed: [October 10, 2003]

9.3.3 Example Do Not Use Notice

WARNING

DO NOT USE THE WATER

[Parathion] found in the [Lyonelle Water System] water supply on [November 14th]

Bottled water can be obtained at [Murray High School and Central High School 24 hours per day].

What is Parathion?
Parathion is a chemical usually used to kill insects. This chemical can make you sick and may result in death.

What should I do?

- DO NOT USE THE WATER. Do ***not*** use the water for drinking, making ice, brushing teeth, washing dishes, washing clothes, bathing/showering, food preparation, or toilet flushing. Bottled water should be used for all of the above necessities until further notice.

What are the symptoms associated with the exposure to parathion?

- It can cause constriction of the pupils, blurred vision, muscle and abdominal cramps, excessive salivation, sweating, nausea, vomiting, dizziness, headaches, convulsions, diarrhea, weakness, labored breathing, wheezing, and unconsciousness. Exposure can even lead to death.
- If you or someone you know exhibits any of these symptoms, immediately contact your health care provider. In addition, please notify [the public health department at 1-800-123-4567].

What happened? What is being done?
The water distribution system was contaminated with parathion. We are working with law enforcement and the public health department to investigate/resolve this issue. We have tested the water in various parts of the distribution system to verify the extent of the parathion contamination. Based on these tests, we have isolated the portion of the system located north of Lincoln Avenue and east of Maple Road. Everyone in this portion of the system **should not use the water**. We have implemented additional security procedures to protect the system against further contamination. Additional information will be provided 24 hours/day on Channel 57 - the local government television channel.

Who do I contact for more information?
For more information, please contact [Joseph Smith] at [555-555-6789]. Additional information is available from the US EPA Safe Drinking Water Hotline at 1-800-426-4794, Poison Control at 1-800-222-1222, and [the Public Health Department Hotline at 1-800-321-4567].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand.

This notice is being sent to you by [Lyonelle Water System]. State Water System ID# [90008]. Date distributed: [November 14, 2003]

9.3.4 Example Notice for an Unknown Contaminant

WARNING

DO NOT USE THE WATER

[Contamination Event] of the [Masterson Water System] water supply on [November 14th]

Bottled water can be obtained at [Fairmont High School and North High School 24 hours per day].

Local authorities have found evidence of contamination of the Masterson Water System.

What should I do?

- DO NOT USE THE WATER. You should ***not*** use the water for drinking, making ice, brushing teeth, washing dishes, washing clothes, bathing/showering, food preparation, or toilet flushing. Bottled water should be used for all of the above necessities until further notice.

What happened? What is being done?
The water distribution system was contaminated with an unknown contaminant. We are working with law enforcement and the public health department to investigate/resolve this issue. We are conducting tests in attempts to identify the contaminant and verify the extent of the contamination. We have implemented additional security procedures to protect the system against further contamination. Additional information will be provided 24 hours/day on Channel 57- the local government television channel.

Who do I contact for more information?
For more information, please contact [Joseph Smith] at [555-555-6789]. Additional information is available from the US EPA Safe Drinking Water Hotline at 1-800-426-4794, Poison Control at 1-800-222-1222, and [the Public Health Department Hotline at 1-800-321-4567].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand.

This notice is being sent to you by [Masterson Water System]. State Water System ID# [90018]. Date distributed: [November 14, 2003]

9.4 Description of the PipelineNet Distribution System Model

PipelineNet was developed by US EPA to simulate the fate and transport of contaminants in water distribution systems, particularly as related to use and application in an emergency response situation. The PipelineNet model allows a user to model the flow and concentration of a biological or chemical contaminant within a water system, thus giving *Water Utility Emergency Response Managers* (WUERMs) real-time information for estimating the risks to public water supplies. This model assesses the effects of water treatment on the contaminant, models the flow and concentration of the contaminant through the water distribution system within a municipality, and estimates the population and infrastructure (e.g., hospitals, schools) at risk. PipelineNet works by integrating the two following computer programs: EPANET and ArcView.

- EPANET performs extended period simulations of hydraulic and water quality behavior within pressurized pipe networks. A network can consist of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated.
- ArcView is a GIS-based desktop mapping software package created by Environmental Systems Research Institute (ESRI) that provides data visualization, query, analysis, and integration capabilities along with the ability to create and edit geographic data. GIS systems use hardware, software, and geographic data to manage geographically referenced information.

This integration gives PipelineNet all the computational (hydraulics and water quality) capabilities of EPANET and all the functionality of ArcView. The integrated system calculates, locates, and maps the population at risk from the introduction of contaminants to the public water supply. The model performs the following functions:

- Simulates the flow and concentration of biological or chemical contaminants in a city or municipality's water distribution system from single and multiple sources if single contaminant.
- Simulates water quality (fate and transport), water tracing, and water aging
- Assesses the effects of water treatment on the contaminant.

Capabilities

Based on an ArcView platform, PipelineNet provides user interfaces to assist with a range of real-time responses and planning scenarios. Although no formal GIS training is required to run PipelineNet, some understanding of these systems will help the user. PipelineNet key capabilities are highlighted below.

Ranking/Prioritization Methodology for Determining Contamination Threat Monitoring Locations. The key questions in the design of a monitoring protocol for a contamination threat is how many samples and where should the samples be collected. Typical sampling and monitoring

locations in distribution systems may include points close to water treatment systems, core business locations, secondary water storage reservoirs, re-pumping or re-treatment facilities and change in water quality. Selection of appropriate monitoring locations should reflect a mix of utility concerns and priorities including:

- Protecting customers with special needs (e.g., hospitals).
- Tracking water quality at or near locations vulnerable to contamination.
- Facilitating suitable response actions to contamination incidents (e.g., ability to isolate the system, or boost chlorine residuals).

US EPA's PipelineNet can be used for determining optimal placement of sampling equipment in the system, to help develop monitoring programs for routine screening of distribution system water quality, and to predict/track the fate and transport of contaminants in a system to effectively respond to a contamination incident. These sampling locations would be tapped for monitoring during a contamination threat.

Figure 5-5 provides a conceptual view of how US EPA's PipelineNet can be used to determine the location of potential monitoring sites for a contamination event.

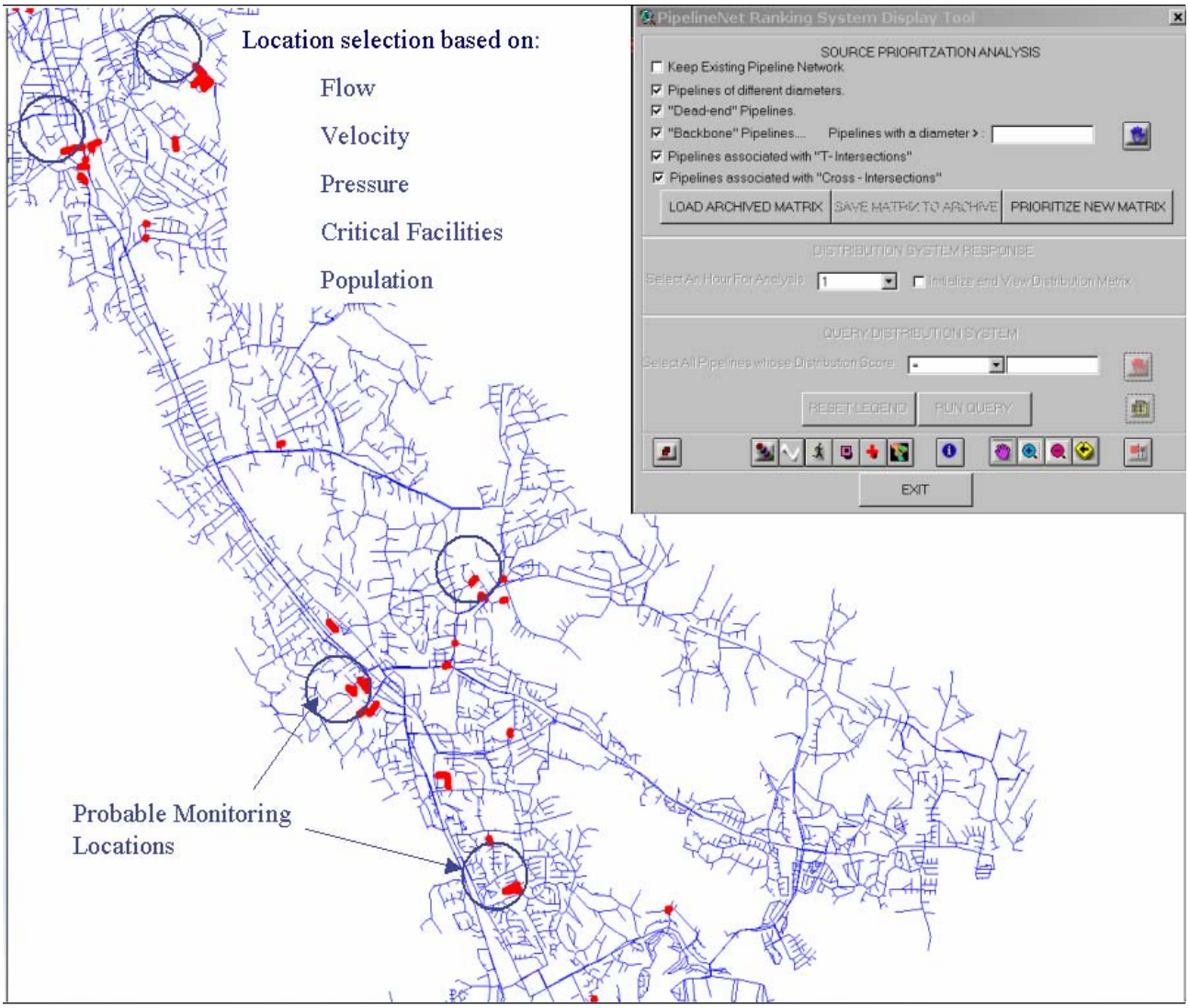


Figure 5-5. Output of Selection Process Showing Potential Monitoring Locations.

Water Quality Simulation. A water quality simulation is initiated through PipelineNet's point and click interface. The user points to a node to introduce a contaminant. An instantaneous or continuous release may be simulated. Additional inputs include mass or concentration, half-life or decay coefficient, length of simulation, and time step. Note that these input parameters are unknown for most contaminants. Therefore, the ability of the model to predict contaminant concentrations that result from decay is limited. Any existing EPANET Pipeline concentration result may be displayed to simulate the contaminant's hourly flow through a pipeline network at anytime (see Figure 5-6). All pipeline concentration results are placed directly in PipelineNet's GIS table of contents.

Water Tracing. Source tracing tracks over time what percent of the water reaching any node in the network had its origin at a particular node. The source node can be any node in the network, including storage nodes. Source tracing is a useful tool for analyzing distribution systems that draw water from two or more different raw water supplies. It can show to what degree water from a given source blends with water from other sources, and how the spatial pattern of this blending changes.

Water Aging. Water age is the time spent by a parcel of water in the network. It provides a simple, non-specific measure of the overall quality of delivered drinking water. New water entering the network from reservoirs or source nodes enters with an age of zero. As this water moves through the pipe network, it splits apart and blends together with parcels of varying age at pipe junctions and storage facilities. EPANET internally treats age as a reactive constituent whose growth follows zero-order kinetics with a rate constant equal to one (i.e., each second the water becomes a second older).

Consequence Assessment Tool. The PipelineNet Consequence Assessment Tool (see Figure 5-7) allows the user to select an area of interest (i.e., region of contaminated pipes) by drawing a rectangle with the help of the cursor on the map in the view. This tool performs the following calculations within the selected area:

- Total population.
- Number of taps.
- Miles of pipe.
- Total number of hospitals and beds for each hospital.
- Total number of schools and enrollment of students.

Isolation Tool. The PipelineNet Isolation Tool (see Figure 5-8) is a post-processing tool that allows the user to change the status (open or closed) of a pipe in the EPANET input file. The model can then be re-run to determine what will happen to the flow by changing the status of the pipe. This tool can be used for public health response planning to determine how best to isolate a portion of the system once it has been contaminated.

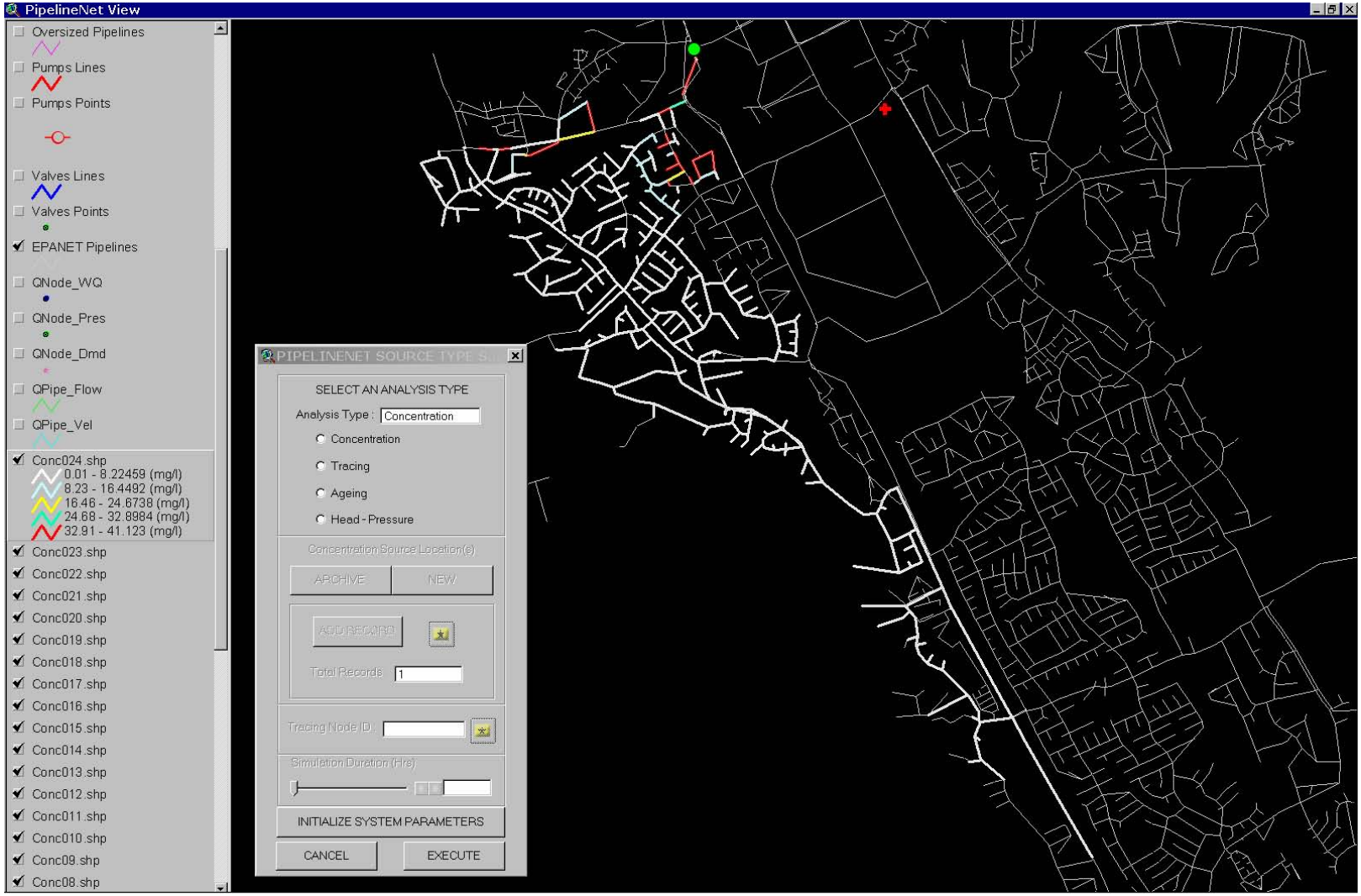


Figure 5-6. Water Quality Simulation.

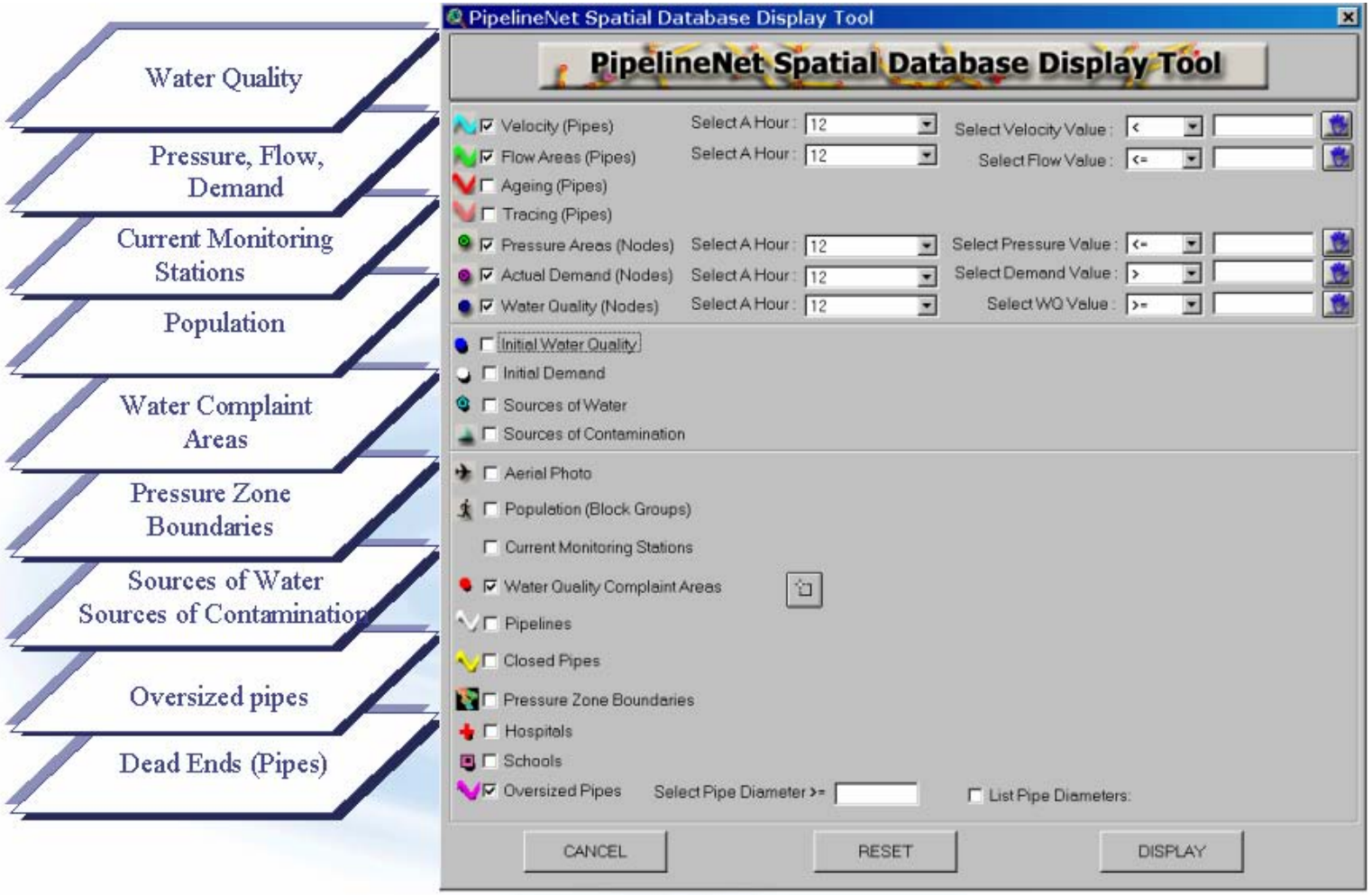


Figure 5-7. Consequence Assessment Tool.

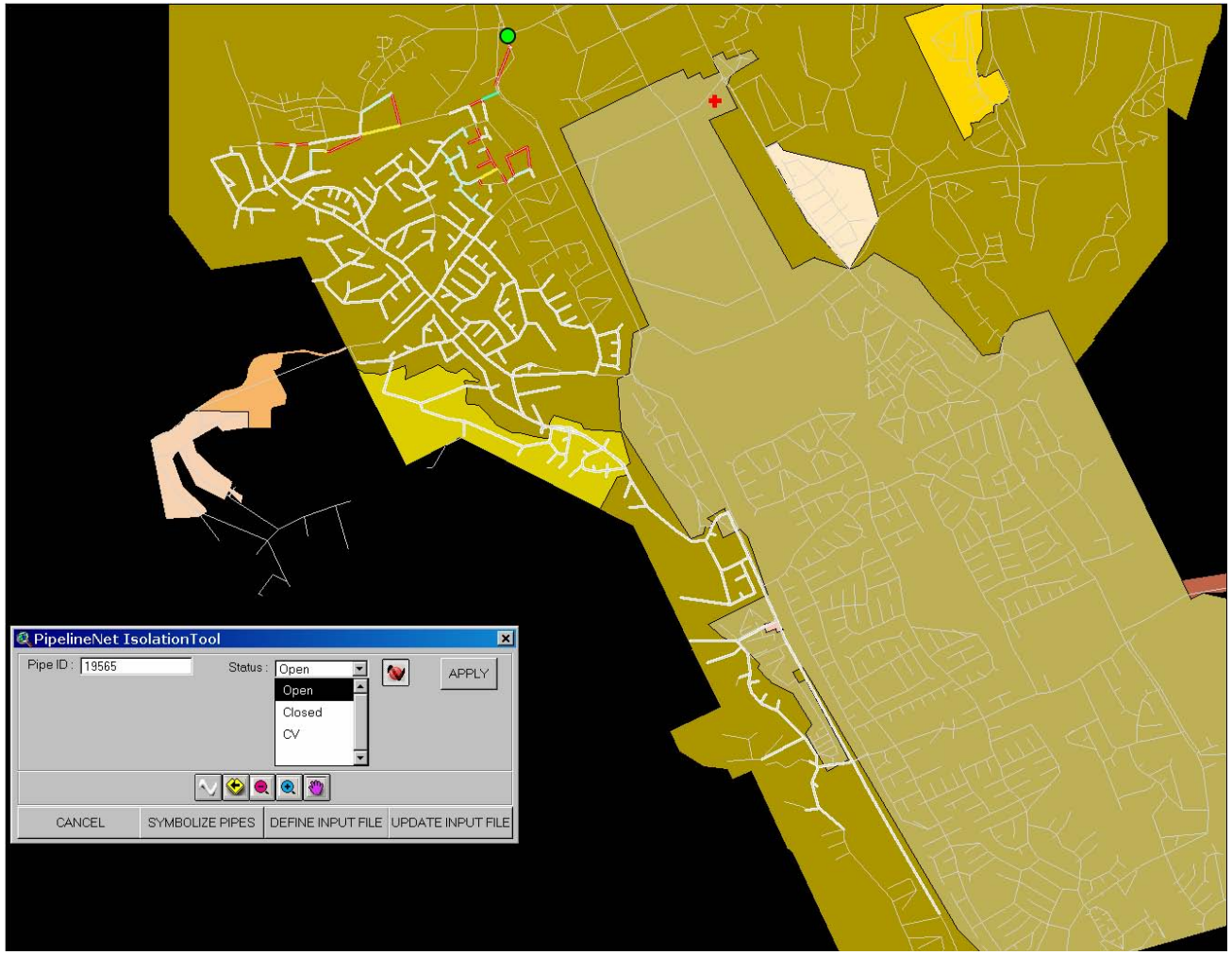


Figure 5-8. Isolation Tool Interface.

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-03-005
www.epa.gov/safewater/security
April 2004

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on
100% Postconsumer, Process Chlorine Free Recycled Paper

United States
Environmental Protection
Agency

Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents

Interim Final - August 2004

Response Guidelines

Response Protocol Toolbox:
Planning for and Responding to
Drinking Water Contamination Threats and Incidents

Response Guidelines

Interim Final - August 2004

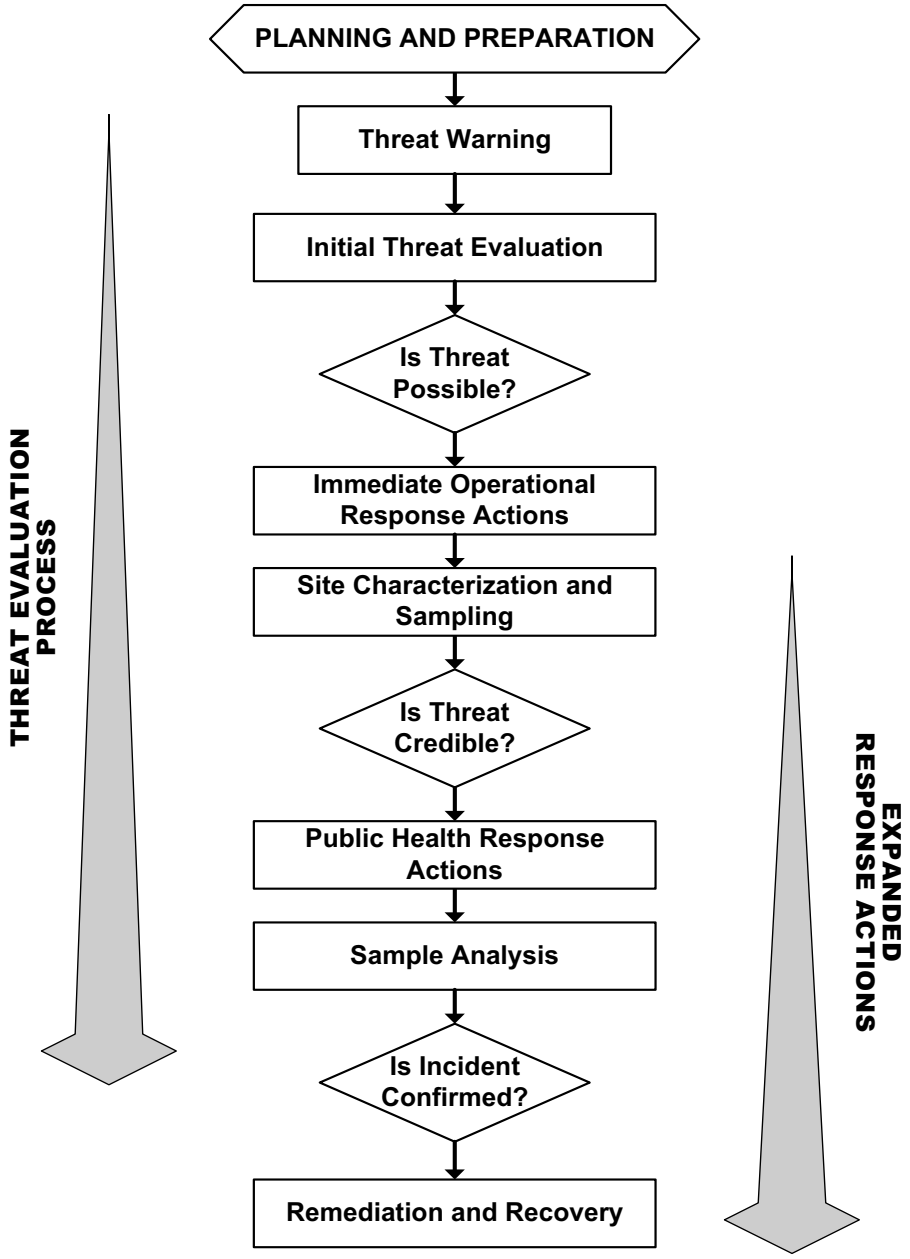


TABLE OF CONTENTS

INTRODUCTION **3**

1 COMMUNICATIONS AND NOTIFICATIONS **4**

1.1 INITIAL NOTIFICATIONS 4
1.2 CONTACT LIST 5

2 THREAT EVALUATION **6**

2.1 THREAT EVALUATION PROCESS 6
2.2 EVALUATING THREAT WARNINGS 7
2.3 THREAT EVALUATION WORKSHEET 8
2.4 SECURITY INCIDENT REPORT FORM 13
2.5 WITNESS ACCOUNT REPORT FORM 16
2.6 PHONE THREAT REPORT FORM 20
2.7 WRITTEN THREAT REPORT FORM 23
2.8 WATER QUALITY/CONSUMER COMPLAINT REPORT FORM 26
2.9 PUBLIC HEALTH INFORMATION REPORT FORM 28

3 SITE CHARACTERIZATION AND SAMPLING **30**

3.1 SITE CHARACTERIZATION PROCESS 30
3.2 EMERGENCY WATER SAMPLE COLLECTION KIT 31
3.3 SAMPLE CONTAINERS 32
3.4 SAMPLE COLLECTION GUIDELINES 34
3.4.1 Safety Guidelines *34*
3.4.2 Sampling Procedures *34*
3.4.3 Sample Holding *35*
3.4.4 Sample Transport *35*
3.5 SITE CHARACTERIZATION PLAN TEMPLATE 36
3.6 SITE CHARACTERIZATION REPORT FORM 40
3.7 FIELD TESTING RESULTS FORM 45
3.8 SAMPLE DOCUMENTATION FORM 46
3.9 CHAIN OF CUSTODY FORM 47

4 SAMPLE ANALYSIS **48**

4.1 LABORATORY CONTACT LIST 48
4.2 GENERAL APPROACH FOR ANALYSIS OF UNKNOWNS IN WATER 49
4.3 GENERAL CLASSES OF CHEMICALS, ANALYTE GROUPS, AND EXAMPLE CONTAMINANTS 50
4.4 GENERAL CLASSES OF PATHOGENS, SPECIFIC ORGANISMS, AND SELECT AGENT STATUS 50

5 RESPONSE ACTIONS **51**

5.1 DECISION TREE FOR CONTAINMENT OPTIONS 51
5.2 DECISION TREE FOR PUBLIC NOTIFICATION 52
5.3 CONTAMINANT CHARACTERIZATION AND TRANSPORT WORKSHEET 53
5.4 PUBLIC HEALTH RESPONSE ACTION WORKSHEET 59

6 APPENDICES **63**

6.1 CRITICAL SYSTEM INFORMATION CHECKLIST 63
6.2 INFORMATION RESOURCES 64
6.3 THREAT MANAGEMENT MATRICES 65
6.3.1 Security Breach *65*
6.3.2 Witness Account *67*
6.3.3 Direct Notification by Perpetrator *68*
6.3.4 Unusual Water Quality or Consumer Complaints *70*
6.3.5 Notification by Public Health *72*

Introduction

The EPA released the interim final *Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents* (the *Response Protocol Toolbox*) in winter of 2003 and spring of 2004 to help the water sector effectively and appropriately plan for and respond to contamination threats and incidents. Since its release, EPA has received feedback and suggestions from several sources concerning improvements in the *Response Protocol Toolbox*. These *Response Guidelines* have been developed to provide an easy to use document for field and crisis conditions. While the *Response Protocol Toolbox* provides detailed information, the *Response Guidelines* are to be viewed as the application of the same principles during an actual incident.

As stated in the definition of Response Guidelines in Module 1, Section 4.3 of the *Response Protocol Toolbox*, Response Guidelines are different from an Emergency Response Plan in that they are essentially a "field guide" for responding to contamination threats and can be developed in many different formats.

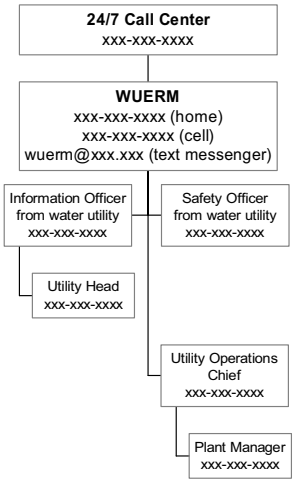
This document is intended to be an action oriented document to assist drinking water utilities, laboratories, emergency responders, state drinking water programs, technical assistance providers, and public health and law enforcement officials during the management of an ongoing contamination threat or incident. The *Response Guidelines* are derived from the content of the six full modules of the *Response Protocol Toolbox*.

The *Response Guidelines* are not intended to replace the *Response Protocol Toolbox* and they do not contain the detailed information contained within the six complete modules. Finally, users are encouraged to adapt the *Response Guidelines* as necessary to meet their own needs and objectives.

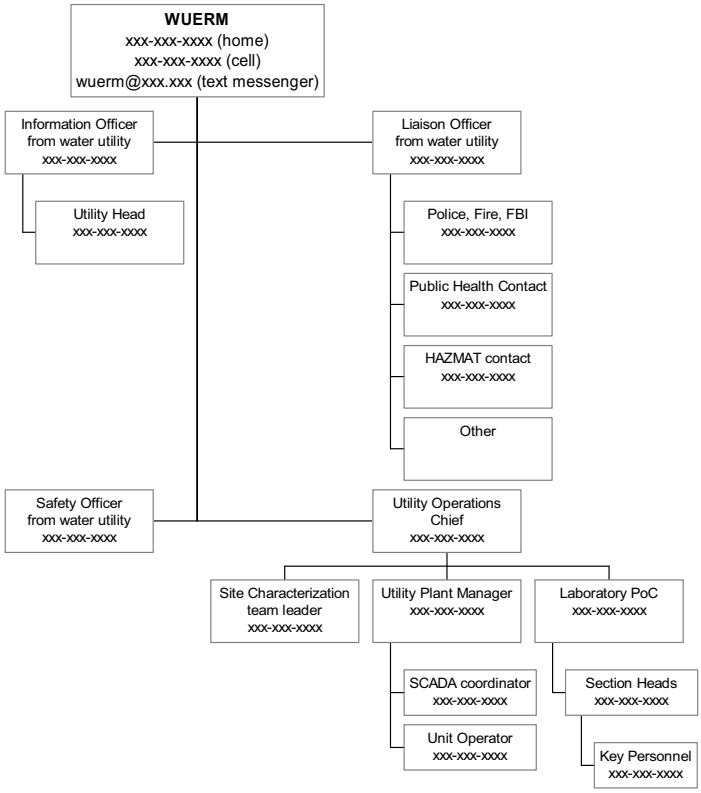
1 Communications and Notifications

1.1 Initial Notifications

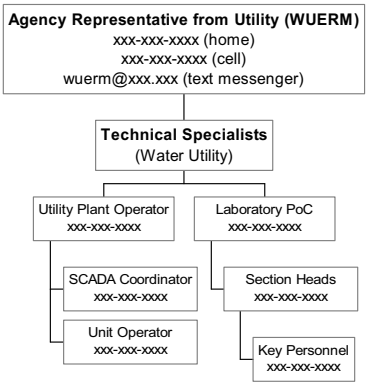
'Possible' stage evaluation by utility



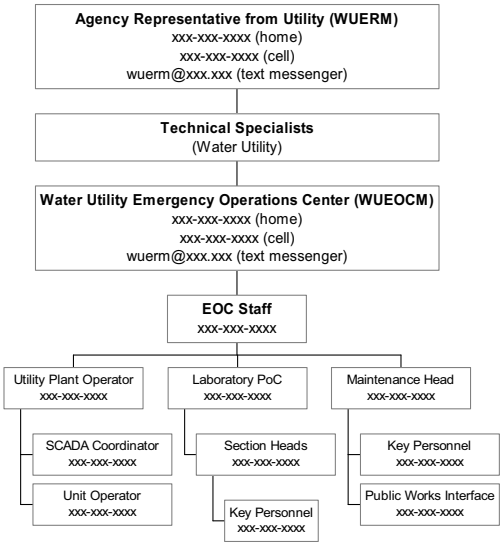
'Credible' stage evaluation by utility



'Credible' stage evaluation by unified command



'Confirmed' stage evaluation by unified command



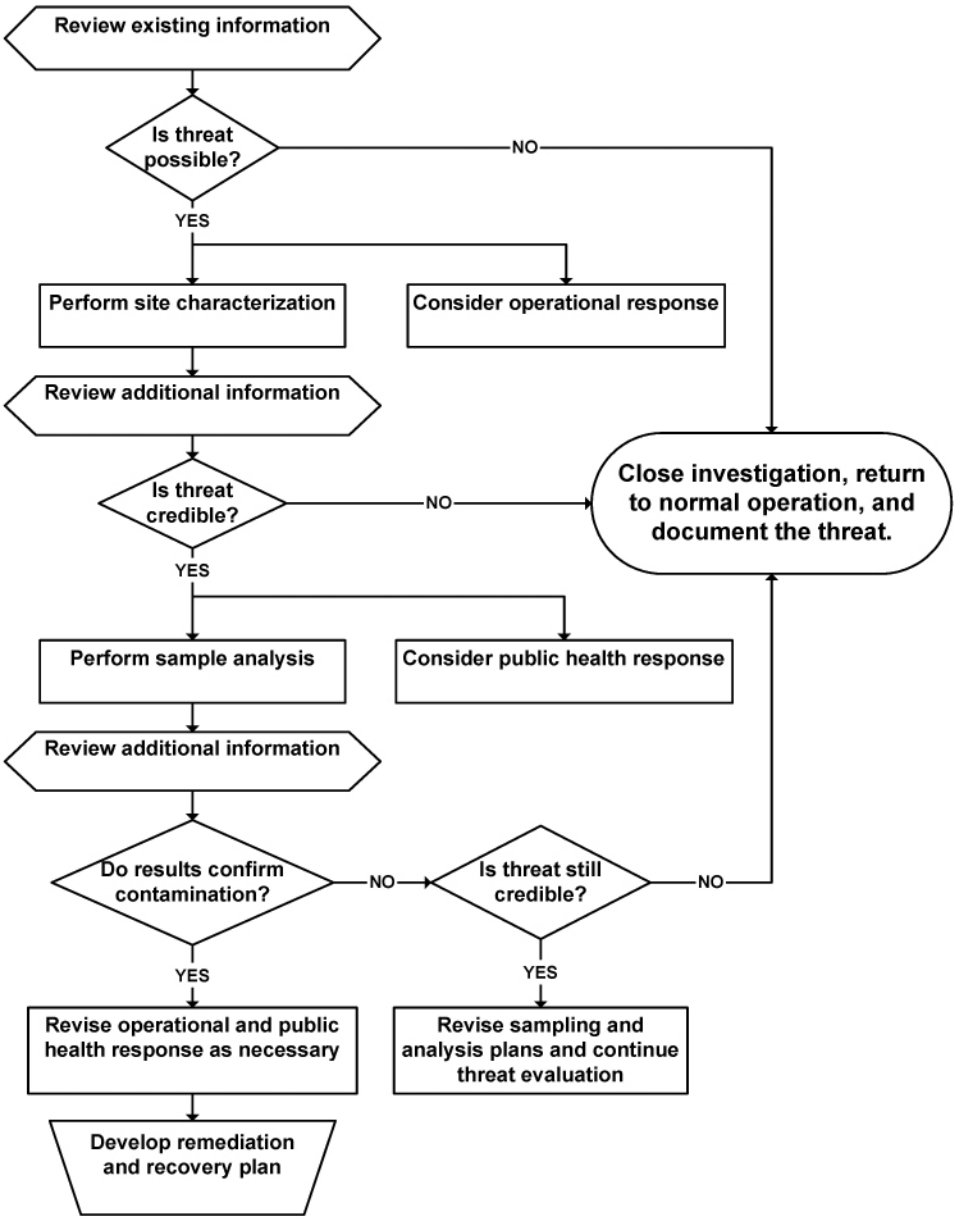
1.2 Contact List

TO BE COMPLETED

Agency	Name	Location	Phone	E-mail

2 Threat Evaluation

2.1 Threat Evaluation Process



2.2 Evaluating Threat Warnings

The first critical step in evaluating a contamination threat is recognition of a *threat warning* (i.e., an unusual situation that may have presented the opportunity for contamination of the drinking water). The utility will likely be in the best position to observe a threat warning and evaluate whether or not the activity is suspicious (i.e., first decision point in the *Threat Evaluation* process). This section briefly describes factors to consider when evaluating various types of threat warnings.

The common types of threat warnings include:

- **Security breaches**: A security breach is an unauthorized intrusion into a secured facility that may be discovered through direct observation, an alarm trigger, or signs of intrusion (e.g., cut locks, open doors, cut fences). Security breaches may be the most common threat warnings, but in **most** cases are related to day-to-day operation and maintenance within the water system. Other security breaches may be due to criminal activity such as trespassing, vandalism, and theft rather than attempts to contaminate the water.
    - Security Incident Report Form → Section 2.4
- **Witness account**: A threat warning may come from an individual who directly witnesses suspicious activity, such as trespassing, breaking and entering, or some other form of tampering. The witness could be a utility employee, law enforcement officer, citizen, etc.
    - Witness Account Report Form → Section 2.5
- **Direct notification by perpetrator**: A threat may be made directly, verbally or in writing, to the water utility, the news media, law enforcement, or a government agency. Verbal threats made over the phone are historically the most common type of direct threats from perpetrators; however, there have also been written threats to contaminate the drinking water supply.
    - Phone Threat Report Form → Section 2.6
    - Written Threat Report Form → Section 2.7
- **Unusual water quality or consumer complaints**: Unusual water quality results or an unexplained or unusually high incidence of consumer complaints may serve as a warning of potential contamination. In order to evaluate this type of warning, it will be necessary to carefully track routinely monitored water quality data and/or consumer complaints such that significant deviations from an established baseline might be observed.
    - Water Quality and Consumer Complaints Report Form → Section 2.8
- **Notification by public health agency**: Notification from a public health agency regarding increased incidence of disease or death is another possible threat warning. A threat triggered by a public health notification is unique in that at least a segment of the population has presumably been exposed to a harmful substance. In this case, public health officials may launch an epidemiological investigation in an attempt to identify the source of the outbreak, during which the utility may be expected to play a support role.
    - Public Health Information Report Form → Section 2.9

2.3 Threat Evaluation Worksheet

INSTRUCTIONS

The purpose of this worksheet is to help organize information about a contamination threat warning that would be used during the Threat Evaluation Process. The individual responsible for conducting the Threat Evaluation (e.g., the WUERM) should complete this worksheet. The worksheet is generic to accommodate information from different types of threat warnings; thus, there will likely be information that is unavailable or not immediately available. Other forms in the Appendices are provided to augment the information in this worksheet.

THREAT WARNING INFORMATION

Date/Time threat warning discovered: _____

Utility Name and Address: _____

Name/Number of person who discovered threat warning: _____

Type of threat warning:

☐ Security breach ☐ Witness account ☐ Phone threat
☐ Written threat ☐ Unusual water quality ☐ Consumer complaints
☐ Public health notification ☐ Other _____

Identity of the contaminant: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

☐ Chemical ☐ Biological ☐ Radiological

Describe _____

_____

Time of contamination: ☐ Known ☐ Estimated ☐ Unknown

If known or estimated, provide additional detail below

Date and time of contamination: _____

Additional Information: _____

_____

Mode of contamination: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Site of contamination: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

Number of sites: _____

Provide the following information for each site.

Site #1

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Site #2

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Site #3

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

ADDITIONAL INFORMATION

Has there been a breach of security at the suspected site? ☐ Yes ☐ No
If "Yes", review the completed 'Security Incident Report' (Section 2.4)

Are there any witness accounts of the suspected incident? ☐ Yes ☐ No
If "Yes", review the completed 'Witness Account Report' (Section 2.5)

Was the threat made verbally over the phone? ☐ Yes ☐ No
If "Yes", review the completed 'Phone Threat Report' (Section 2.6)

Was a written threat received? ☐ Yes ☐ No
If "Yes", review the completed 'Written Threat Report' (Section 2.7)

Are there unusual water quality data or consumer complaints? ☐ Yes ☐ No
If "Yes", review the completed 'Water Quality/Consumer Complaint Report' (Section 2.8)

Are there unusual symptoms or disease in the population? ☐ Yes ☐ No
If "Yes", review the completed 'Public Health Report' (Section 2.9)

Is a 'Site Characterization Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Site Characterization Report' (Section 3.4)

Are results of sample analysis available? ☐ Yes ☐ No
If "Yes", review the analytical results report, including appropriate QA/QC data

Is a 'Contaminant Identification Report' available? ☐ Yes ☐ No
If "Yes", review the completed 'Sample Analysis Report' (Section 4.3)

Is there relevant information available from external sources? ☐ Yes ☐ No
Check all that apply

☐ Local law enforcement	☐ FBI	☐ DW primacy agency
☐ Public health agency	☐ Hospitals / 911 call centers	☐ US EPA / Water ISAC
☐ Media reports	☐ Homeland security alerts	☐ Neighboring utilities

☐ Other _____

Point of Contact: _____

_____

Summary of key information from external sources (provide detail in attachments as necessary):

_____

_____

_____

_____

_____

_____

THREAT EVALUATION

Has normal activity been investigated as the cause of the threat warning? ☐ Yes ☐ No

Normal activities to consider

- ☐ Utility staff inspections
- ☐ Construction or maintenance
- ☐ Operational changes
- ☐ Routine water quality sampling
- ☐ Contractor activity
- ☐ Water quality changes with a known cause
- ☐ Other _____

Is the threat 'possible'? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a 'possible' threat:

- ☐ None
- ☐ Increased monitoring/security
- ☐ Site characterization
- ☐ Other _____
- ☐ Isolation/containment

Is the threat 'credible'? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a 'credible' threat:

- ☐ Sample analysis
- ☐ Partial EOC activation
- ☐ Other _____
- ☐ Site characterization
- ☐ Public notification
- ☐ Isolation/containment
- ☐ Provide alternate water supply

Has a contamination incident been confirmed? ☐ Yes ☐ No

Summarize the basis for this determination: _____

_____

_____

Response to a confirmed incident:

- ☐ Sample analysis
- ☐ Full EOC activation
- ☐ Initiate remediation and recovery
- ☐ Other _____
- ☐ Site characterization
- ☐ Public notification
- ☐ Isolation/containment
- ☐ Provide alternate water supply

How do other organizations characterize the threat?

Organization	Evaluation	Comment
☐ Local Law Enforcement	☐ Possible ☐ Credible ☐ Confirmed	
☐ FBI	☐ Possible ☐ Credible ☐ Confirmed	
☐ Public Health Agency	☐ Possible ☐ Credible ☐ Confirmed	
☐ Drinking Water Primacy Agency	☐ Possible ☐ Credible ☐ Confirmed	
☐ Other	☐ Possible ☐ Credible ☐ Confirmed	
☐ Other	☐ Possible ☐ Credible ☐ Confirmed	

SIGNOFF

Name of person completing this form:

Print name _____ Phone Number _____

Signature _____ Date/Time: _____

2.4 Security Incident Report Form

INSTRUCTIONS

The purpose of this form is to help organize information about a security incident, typically a security breach, which may be related to a water contamination threat. The individual who discovered the security incident, such as a security supervisor, the WUERM, or another designated individual may complete this form. This form is intended to summarize information about a security breach that may be relevant to the threat evaluation process. This form should be completed for each location where a security incident was discovered.

DISCOVERY OF SECURITY INCIDENT

Date/Time security incident discovered: _____

Name of person who discovered security incident: _____

Mode of discovery:

- ☐ Alarm (building)
- ☐ Alarm (gate/fence)
- ☐ Alarm (access hatch)
- ☐ Video surveillance
- ☐ Utility staff discovery
- ☐ Citizen discovery
- ☐ Suspect confession
- ☐ Law enforcement discovery
- ☐ Other _____

Did anyone observe the security incident as it occurred? ☐ Yes ☐ No

If "Yes", complete the 'Witness Account Report' (Appendix 8.4)

SITE DESCRIPTION

Site Name: _____

Type of facility

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank
- ☐ Elevated storage tank
- ☐ Finished water reservoir
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

BACKGROUND INFORMATION

Have the following "normal activities" been investigated as potential causes of the security incident?

- ☐ Alarms with known and harmless causes
- ☐ Utility staff inspections
- ☐ Routine water quality sampling
- ☐ Construction or maintenance
- ☐ Contractor activity
- ☐ Other _____

Was this site recently visited *prior* to the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of previous visit: _____

Name of individual who visited the site: _____

Additional Information: _____
_____

Has *this location* been the site of previous security incidents? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of most recent security incident: _____

Description of incident: _____
_____
_____

What were the results of the threat evaluation for this incident?
☐ 'Possible' ☐ 'Credible' ☐ 'Confirmed'

Have security incidents occurred at *other locations* recently? ☐ Yes ☐ No
If "Yes", complete additional 'Security Incident Reports' (Appendix 8.3) for each site

Name of 1st additional site: _____
Name of 2nd additional site: _____
Name of 3rd additional site: _____

SECURITY INCIDENT DETAILS

Was there an alarm(s) associated with the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Are there sequential alarms (e.g., alarm on a gate and a hatch)? ☐ Yes ☐ No

Date and time of alarm(s): _____

Describe alarm(s): _____
_____

Is video surveillance available from the site of the security incident? ☐ Yes ☐ No
If "Yes," provide additional detail below

Date and time of video surveillance: _____

Describe surveillance: _____
_____
_____
_____

Unusual equipment found at the site and time of discovery of the security incident:

- ☐ Discarded PPE (e.g., gloves, masks)
- ☐ Tools (e.g., wrenches, bolt cutters)
- ☐ Lab equipment (e.g., beakers, tubing)
- ☐ None
- ☐ Empty containers (e.g., bottles, drums)
- ☐ Hardware (e.g., valves, pipe)
- ☐ Pumps or hoses
- ☐ Other _____

Describe equipment: _____

Unusual vehicles found at the site and time of discovery of the security incident:

- ☐ Car/sedan
- ☐ Flatbed truck
- ☐ SUV
- ☐ Construction vehicle
- ☐ Pickup truck
- ☐ None
- ☐ Other _____

Describe vehicles (including make/model/year/color, license plate #, and logos or markings): ____

Signs of tampering at the site and time of discovery of the security incident:

- ☐ Cut locks/fences
- ☐ Open/damaged access hatches
- ☐ Facility in disarray
- ☐ Open/damaged gates, doors, or windows
- ☐ Missing/damaged equipment
- ☐ None
- ☐ Other _____

Are there signs of sequential intrusion (e.g., locks removed from a gate and hatch)? ☐ Yes ☐ No

Describe signs of tampering: _____

Signs of hazard at the site and time of discovery of the security incident:

- ☐ Unexplained or unusual odors
- ☐ Unexplained dead or stressed vegetation
- ☐ Unexplained clouds or vapors
- ☐ Unexplained dead animals
- ☐ Unexplained liquids
- ☐ None
- ☐ Other _____

Describe signs of hazard: _____

SIGNOFF

Name of person responsible for documenting the security incident:

Print name _____

Signature _____ Date/Time: _____

2.5 Witness Account Report Form

INSTRUCTIONS

The purpose of this form is to document the observations of a witness to activities that might be considered an incident warning. The individual interviewing the witness, or potentially the witness, should complete this form. This may be the WUERM or an individual designated by incident command to perform the interview. If law enforcement is conducting the interview (which may often be the case), then this form may serve as a prompt for "utility relevant information" that should be pursued during the interview. This form is intended to consolidate the details of the witness account that may be relevant to the threat evaluation process. This form should be completed for each witness that is interviewed.

BASIC INFORMATION

Date/Time of interview: _____

Name of person interviewing the witness: _____

Witness contact information

Full Name: _____

Address: _____

Day-time phone: _____

Evening phone: _____

E-mail address: _____

Reason the witness was in the vicinity of the suspicious activity: _____

_____

_____

WITNESS ACCOUNT

Date/Time of activity: _____

Location of activity:

Site Name: _____

Type of facility

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank
- ☐ Elevated storage tank
- ☐ Finished water reservoir
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Type of activity

☐ Trespassing ☐ Vandalism ☐ Breaking and entering
☐ Theft ☐ Tampering ☐ Surveillance
☐ Other _____

Additional description of the activity _____
_____
_____
_____
_____

Description of suspects

Were suspects present at the site? ☐ Yes ☐ No

How many suspects were present? _____

Describe each suspect's appearance:

Suspect #	Sex	Race	Hair color	Clothing	Voice
1					
2					
3					
4					
5					
6					

Where any of the suspects wearing uniforms? ☐ Yes ☐ No
If "Yes," describe the uniform(s): _____
_____

Describe any other unusual characteristics of the suspects: _____
_____
_____
_____
_____

Did any of the suspects notice the witness? ☐ Yes ☐ No
If "Yes," how did they respond: _____
_____

Vehicles at the site

Were vehicles present at the site? ☐ Yes ☐ No

Did the vehicles appear to belong to the suspects? ☐ Yes ☐ No

How many vehicles were present? _____

Describe each vehicle:

Vehicle #	Type	Color	Make	Model	License plate
1					
2					
3					
4					
5					
6					

Where there any logos or distinguishing markings on the vehicles? ☐ Yes ☐ No
If "Yes," describe: _____

Provide any additional detail about the vehicles and how they were used (if at all): _____

Equipment at the site

Was any unusual equipment present at the site? ☐ Yes ☐ No

☐ Explosive or incendiary devices
☐ PPE (e.g., gloves, masks)
☐ Tools (e.g., wrenches, bolt cutters)
☐ Lab equipment (e.g., beakers, tubing)
☐ Firearms
☐ Containers (e.g., bottles, drums)
☐ Hardware (e.g., valves, pipe, hoses)
☐ Pumps and related equipment
☐ Other _____

Describe the equipment and how it was being used by the suspects (if at all): _____

Unusual conditions at the site

Were there any unusual conditions at the site? ☐ Yes ☐ No

☐ Explosions or fires
☐ Dead/stressed vegetation
☐ Fogs or vapors
☐ Dead animals
☐ Unusual odors
☐ Unusual noises
☐ Other _____

Describe the site conditions: _____

Additional observations

Describe any additional details from the witness account: _____

_____

_____

_____

_____

_____

SIGNOFF

Name of interviewer:

Print name _____

Signature _____ Date/Time: _____

Name of witness:

Print name _____

Signature _____ Date/Time: _____

2.6 Phone Threat Report Form

INSTRUCTIONS

This form is intended to be used by utility staff that regularly answer phone calls from the public (e.g., call center operators). The purpose of this form is to help these staff capturer as much information from a threatening phone call while the caller is on the line. It is important that the operator keep the caller on the line as long as possible in order to collect additional information. Since this form will be used during the call, it is important that operators become familiar with the content of the form. The sections of the form are organized with the information that should be collected during the call at the front of the form (i.e., Basic Call Information and Details of Threat) and information that can be completed immediately following the call at the end of the form (i.e., the description of the caller). The information collected on this form will be critical to the threat evaluation process.

Remember, tampering with a drinking water system is a crime under the SDWA Amendments!

THREAT NOTIFICATION

Name of person receiving the call: _____

Date phone call received: _____ **Time phone call received:** _____

Time phone call ended: _____ **Duration of phone call:** _____

Originating number: _____ **Originating name:** _____

*If the number/name is not displayed on the caller ID, press *57 (or call trace) at the end of the call and inform law enforcement that the phone company may have trace information.*

Is the connection clear? ☐ Yes ☐ No

Could call be from a wireless phone? ☐ Yes ☐ No

DETAILS OF THREAT

Has the water already been contaminated? ☐ Yes ☐ No

Date and time of contaminant introduction known? ☐ Yes ☐ No

Date and time if known: _____

Location of contaminant introduction known? ☐ Yes ☐ No

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Name or type of contaminant known? ☐ Yes ☐ No

Type of contaminant

☐ Chemical ☐ Biological ☐ Radiological

Specific contaminant name/description: _____

_____

Mode of contaminant introduction known? ☐ Yes ☐ No

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Motive for contamination known? ☐ Yes ☐ No

☐ Retaliation/revenge ☐ Political cause ☐ Religious doctrine

☐ Other _____

Describe motivation: _____

_____

CALLER INFORMATION

Basic Information:

Stated name: _____

Affiliation: _____

Phone number: _____

Location/address: _____

Caller's Voice:

Did the voice sound disguised or altered? ☐ Yes ☐ No

Did the call sound like a recording? ☐ Yes ☐ No

Did the voice sound? ☐ Male / ☐ Female ☐ Young / ☐ Old

Did the voice sound familiar? ☐ Yes ☐ No

If 'Yes,' who did it sound like? _____

Did the caller have an accent? ☐ Yes ☐ No

If 'Yes,' what nationality? _____

How did the caller sound or speak?

☐ Educated ☐ Well spoken ☐ Illiterate

☐ Irrational ☐ Obscene ☐ Incoherent

☐ Reading a script ☐ Other _____

What was the caller's tone of voice?

☐ Calm	☐ Angry	☐ Lisping	☐ Stuttering/broken
☐ Excited	☐ Nervous	☐ Sincere	☐ Insincere
☐ Slow	☐ Rapid	☐ Normal	☐ Slurred
☐ Soft	☐ Loud	☐ Nasal	☐ Clearing throat
☐ Laughing	☐ Crying	☐ Clear	☐ Deep breathing
☐ Deep	☐ High	☐ Raspy	☐ Cracking

☐ Other _____

Were there background noises coming from the caller's end?

☐ Silence		
☐ Voices	describe	_____
☐ Children	describe	_____
☐ Animals	describe	_____
☐ Factory sounds	describe	_____
☐ Office sounds	describe	_____
☐ Music	describe	_____
☐ Traffic/street sounds	describe	_____
☐ Airplanes	describe	_____
☐ Trains	describe	_____
☐ Ships or large boats	describe	_____

☐ Other: _____

SIGNOFF

Name of call recipient:

Print name _____

Signature _____ Date/Time: _____

Name of person completing form (if different from call recipient):

Print name _____

Signature _____ Date/Time: _____

2.7 Written Threat Report Form

INSTRUCTIONS

The purpose of this form is to summarize significant information from a written threat received by a drinking water utility. This form should be completed by the WUERM or an individual designated by incident command to evaluate the written threat. The summary information provided in this form is intended to support the threat evaluation process; however, the completed form is not a substitute for the complete written threat, which may contain additional, significant details.

The written threat itself (e.g., the note, letter, e-mail message, etc.) may be considered evidence and thus should be minimally handled (or not handled at all) and placed into a clean plastic bag to preserve any forensic evidence.

Remember, tampering with a drinking water system is a crime under the SDWA Amendments!

SAFETY

A suspicious letter or package could pose a threat in and of itself, so caution should be exercised if such packages are received. The US Postal Service has issued guidance when dealing with suspicious packages (http://www.usps.com/news/2001/press/pr01_1022gsa.htm).

THREAT NOTIFICATION

Name of person receiving the written threat: _____

Person(s) to whom threat was addressed: _____

Date threat received: _____ **Time threat received:** _____

How was the written threat received?

☐ US Postal service ☐ Delivery service ☐ Courier
☐ Fax ☐ E-mail ☐ Hand delivered
☐ Other _____

If mailed, is the return address listed? ☐ Yes ☐ No

_____

_____

If mailed, what is the date and location of the postmark? _____

_____

If delivered, what was the service used (list any tracking numbers)? _____

_____

If Faxed, what is the number of the sending fax? _____

If E-mailed, what is the e-mail address of sender? _____

_____

If hand-delivered, who delivered the message? _____

_____

DETAILS OF THREAT

Has the water already been contaminated? ☐ Yes ☐ No

Date and time of contaminant introduction known? ☐ Yes ☐ No

Date and time if known: _____

Location of contaminant introduction known? ☐ Yes ☐ No

Site Name: _____

Type of facility

☐ Source water ☐ Treatment plant ☐ Pump station
☐ Ground storage tank ☐ Elevated storage tank ☐ Finished water reservoir
☐ Distribution main ☐ Hydrant ☐ Service connection
☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

Name or type of contaminant known? ☐ Yes ☐ No

Type of contaminant

☐ Chemical ☐ Biological ☐ Radiological

Specific contaminant name/description: _____

_____

Mode of contaminant introduction known? ☐ Yes ☐ No

Method of addition: ☐ Single dose ☐ Over time ☐ Other _____

Amount of material: _____

Additional Information: _____

_____

Motive for contamination known? ☐ Yes ☐ No

☐ Retaliation/revenge ☐ Political cause ☐ Religious doctrine
☐ Other _____

Describe motivation: _____

_____

NOTE CHARACTERISITCS

Perpetrator Information:

Stated name: _____
Affiliation: _____
Phone number: _____
Location/address: _____

Condition of paper/envelop:

- ☐ Marked personal
- ☐ Marked confidential
- ☐ Properly addressed
- ☐ Neatly typed or written
- ☐ Clean
- ☐ Corrected or marked-up
- ☐ Crumpled or wadded up
- ☐ Soiled/stained
- ☐ Torn/tattered
- ☐ Other: _____

How was the note prepared?

- ☐ Handwritten in print
- ☐ Handwritten in script
- ☐ Computer typed
- ☐ Machine typed
- ☐ Spliced (e.g., from other typed material)
- ☐ Other: _____

If handwritten, does writing look familiar? ☐ Yes ☐ No

_____

Language:

- ☐ Clear English
- ☐ Poor English
- ☐ Another language: _____
- ☐ Mixed languages: _____

Writing Style

- ☐ Educated
- ☐ Proper grammar
- ☐ Logical
- ☐ Uneducated
- ☐ Poor grammar/spelling
- ☐ Incoherent
- ☐ Use of slang
- ☐ Obscene
- ☐ Other: _____

Writing Tone

- ☐ Clear
- ☐ Direct
- ☐ Sincere
- ☐ Condescending
- ☐ Accusatory
- ☐ Angry
- ☐ Agitated
- ☐ Nervous
- ☐ Irrational
- ☐ Other: _____

SIGNOFF

Name of individual who received the threat:

Print name _____

Signature _____ Date/Time: _____

Name of person completing form (if different from written threat recipient):

Print name _____

Signature _____ Date/Time: _____

2.8 Water Quality/Consumer Complaint Report Form

INSTRUCTIONS

This form is provided to guide the individual responsible for evaluating unusual water quality data or consumer complaints. It is designed to prompt the analyst to consider various factors or information when evaluating the unusual data. The actual data used in this analysis should be compiled separately and appended to this form. The form can be used to support the threat evaluation due to a threat warning from unusual water quality or consumer complaints, or another type of threat warning in which water quality data or consumer complaints are used to support the evaluation.

Note that in this form, water quality refers to both specific water quality parameters and the general aesthetic characteristics of the water that might result in consumer complaints.

Threat warning is based on: ☐ Water quality ☐ Consumer complaints ☐ Other

What is the water quality parameter or complaint under consideration?

Are unusual consumer complaints corroborated by unusual water quality data?

Is the unusual water quality indicative of a particular contaminant of concern? For example, is the color, order, or taste associated with a particular contaminant?

Are consumers in the affected area experiencing any unusual health symptoms?

What is 'typical' for consumer complaints for the current season and water quality?

Number of complaints.
Nature of complaints.
Clustering of complaints

What is considered to be 'normal' water quality (i.e., what is the baseline water quality data or level of consumer complaints)?

What is reliability of the method or instrumentation used for the water quality analysis?

Are standards and reagents OK?
Is the method/instrument functioning properly?

Based on recent data, does the unusual water quality appear to be part of a gradual trend (i.e., occurring over several days or longer)?

Are the unusual water quality observations sporadic over a wide area, or are they clustered in a particular area?

What is the extent of the area? A pressure zone. A neighborhood. A city block. A street. A building.

If the unusual condition isolated to a specific area:

Is this area being supplied by a particular plant or source water?
Have there been any operational changes at the plant or in the affected area of the system?
Has there been any flushing or distribution system maintenance in the affected area?
Has there been any repair or construction in the area that could impact water quality?

SIGNOFF

Name of person completing form:

Print name _____

Signature _____ Date/Time: _____

2.9 Public Health Information Report Form

INSTRUCTIONS

The purpose of this form is to summarize significant information about a public health episode that could be linked to contaminated water. This form should be completed by the WUERM or an individual designated by incident command. The information compiled in this form is intended to support the threat evaluation process.

In the case of a threat warning due to a report from public health, it is likely that the public health agency will assume incident command during the investigation. The drinking water utility will likely play a support role during the investigation, specifically to help determine whether or not water might be the cause.

PUBLIC HEALTH NOTIFICATION

Date and Time of notification: _____ _____

Name of person who received the notification: _____

Contact information for individual providing the notification

Full Name: _____
Title: _____
Organization: _____
Address: _____
Day-time phone: _____
Evening phone: _____
Fax Number: _____
E-mail address: _____

Why is this person contacting the drinking water utility? _____
_____
_____

Has the state or local public health agency been notified? ☐ Yes ☐ No

If "No," the appropriate public health official should be immediately notified.

DESCRIPTION OF PUBLIC HEALTH EPISODE

Nature of public health episode:

☐ Unusual disease (mild) ☐ Unusual disease (severe) ☐ Death
☐ Other: _____

Symptoms:

☐ Diarrhea ☐ Vomiting/nausea ☐ Flu-like symptoms
☐ Fever ☐ Headache ☐ Breathing difficulty
☐ Other: _____

Describe symptoms: _____
_____

Causative Agent: ☐ Known ☐ Suspected ☐ Unknown

If known or suspected, provide additional detail below

☐ Chemical ☐ Biological ☐ Radiological

Describe _____
_____

Estimate of time between exposure and onset of symptoms: _____

Exposed Individuals:

Location where exposure is thought to have occurred

☐ Residence ☐ Work ☐ School
☐ Restaurant ☐ Shopping mall ☐ Social gathering
☐ Other: _____

Additional notes on location of exposure: _____
_____

Collect addresses for specific locations where exposure is thought to have occurred.

Is the pattern of exposure clustered in a specific area? ☐ Yes ☐ No

Extent of area

☐ Single building ☐ Complex (several buildings) ☐ City block
☐ Neighborhood ☐ Cluster of neighborhoods ☐ Large section of city
☐ Other: _____

Additional notes on extent of area: _____
_____

Do the exposed individuals represent a disproportionate number of:

☐ Immune compromised ☐ Elderly ☐ Children
☐ Infants ☐ Pregnant women ☐ Women
☐ Other: _____
☐ None, no specific groups dominate the makeup of exposed individuals

EVALUATION OF LINK TO WATER

Are the symptoms consistent with typical waterborne diseases, such as gastrointestinal disease, vomiting, or diarrhea? ☐ Yes ☐ No

Does the area of exposure coincide with a specific area of the system, such as a pressure zone or area feed by a specific plant? ☐ Yes ☐ No

Were there any consumer complaints within the affected area? ☐ Yes ☐ No

Were there any unusual water quality data within the affected area? ☐ Yes ☐ No

Were there any process upsets or operational changes? ☐ Yes ☐ No

Was there any construction/maintenance within the affected area? ☐ Yes ☐ No

Were there any security incidents within the affected area? ☐ Yes ☐ No

---

SIGNOFF

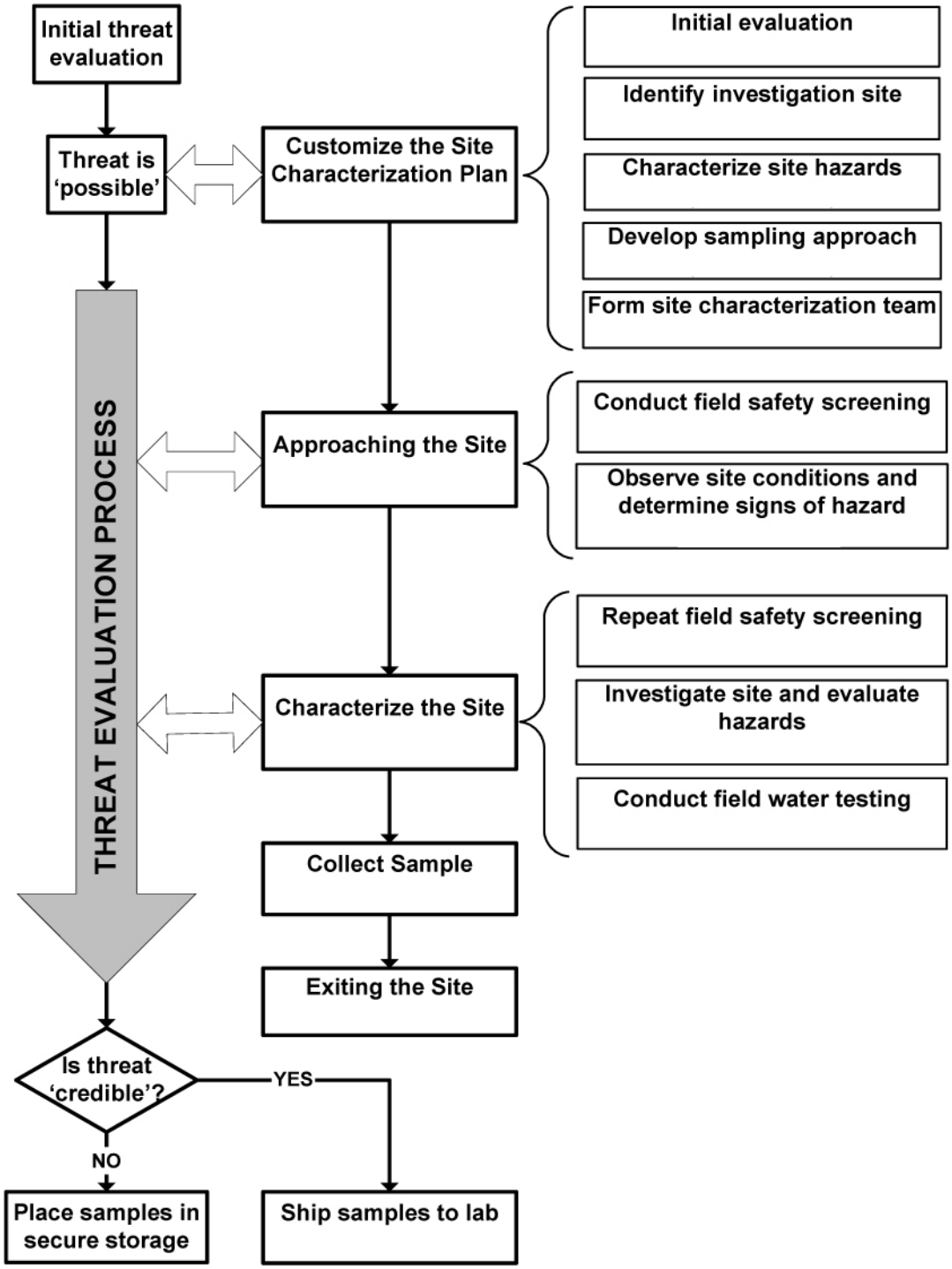
Name of person completing form:

Print name _____

Signature _____ Date/Time: _____

3 Site Characterization and Sampling

3.1 Site Characterization Process



3.2 Emergency Water Sample Collection Kit

Item	Quantity	Notes
Field Resources and Documentation		
Field guide	2	Resource for field personnel
Health and safety plan	2	If required for the site
Sample labels	48	Waterproof (filled out in advance, if possible)
Sample documentation forms	24	For recording sample information
Custody tape (or seals)	2 rolls	Used on sample or shipping containers
Chain of custody forms	24	For documenting sample custody
Lab marker	2	Waterproof, 1 red, 1 black
General Sampling Supplies		
Sample containers	Table 3-2	For collecting samples
Device for grab sampling	1	For sampling large water bodies
10 liter HDPE container	4	For collection of large volume water samples
Lab grade tape	3 rolls	For temporary labeling in the field
Miscellaneous glassware	N/A	Beakers, graduated cylinders, spatula, etc.
Collapsible cooler	1	For sample storage
Rigid shipping container	1	For shipping by overnight service if needed.
1 qt. zippered freezer bags	1 pack100	For double bagging ice and sample containers
Thermometer	2	For checking water temperature
Paper towels	2 rolls	Wiping wet containers and containing spills
Pathogen Sampling Supplies		
Tubing and clamp	1	For sample tap flushing, etc.
Stopwatch & graduated cylinder	1	For measuring flow rate
Ultrafiltration apparatus	1	For concentrating pathogen samples
Reagents (may need to be kept separate from the rest of the kit)		
Laboratory grade water	5 liters	For sample dilution in the field
Sodium thiosulfate crystals	100 grams	For water sample dechlorination
Ascorbic acid	100 grams	For water sample dechlorination
Sodium sulfite crystals	100 grams	For water sample dechlorination
Potassium dihydrogen citrate	100 grams	For carbamate preservation
6 Molar ACS grade hydrochloric acid (HCl)	25 mL	In dropper bottle for preservation of samples for organic analyses
6 Molar trace metal-grade nitric acid (HNO_3)	25 mL	In dropper bottle for preservation of samples for trace metals analysis
10 Normal Sodium hydroxide (NaOH)	25 mL	In dropper bottle for preservation of samples for cyanide analyses
pH paper in ranges from 0 - 4 and 10 - 14	50 strips	For checking the pH of samples preserved with acid or base (sensitive to 0.5 pH units)
Safety Supplies		
Splash resistant goggles	2	One per individual (minimum)
Disposable gloves	6 pairs	Nitrile or polyethylene, powder-free
Disposable shoe covers	2 pairs	One pair per individual (minimum)
Disposable laboratory coats	2	One per individual (minimum)
Clear, heavy duty plastic trash bags	4	For disposal of lab coat, gloves, etc.
Rinse water	20 liters	For general use and first aid
Antiseptic wipes	1 container	For cleaning hands, sample containers, etc.
Bleach solution (at least 5%)	1 gallon	For decontamination if necessary
Squirt bottle	2	For use with rinse water or lab grade water
First aid kit	1	For general first aid
Flashlight/headlamp	3	For working at night or in dark locations

3.3 Sample Containers

Sample Type	Container Size	Container Type	No.	Dechlorinating Agent	Preservative	Analytical Technique	Reference Methods
CHEMISTRY - BASIC SCREEN (Established Techniques)							
Organic Analytes							
Volatiles	40 mL	Glass w / Teflon faced septa	5	Ascorbic acid	1:1 HCl to pH < 2 See method.	P&T – GC/MS	EPA 524.2, 8260B
						P&T – GC/PID/ELCD	EPA 502.2, 8021B
Semi-volatiles	1 L	Amber w / Teflon-lined screw caps	4	Sodium sulfite	6M HCl. See method.	SPE GC/MS	525.2, 8270D/3535
Quarternary nitrogen compounds	1 L	Amber PVC or silanized glass	4	Sodium thiosulfate	Sulfuric acid to pH 2	SPE HPLC - UV	549.2
Carbamate Pesticides	40 mL	Glass w / Teflon faced septa	4	Sodium thiosulfate	Potassium dihydrogen citrate sample pH to ~3.8	HPLC-fluorescence	531.2
Inorganic Analytes							
Metals/Elements	125 mL	Plastic (i.e. HPDE)	2	None	Trace metal grade nitric acid. See method.	ICP-MS	200.8
						ICP-AES	200.7
						AA	200.9
Organometallic compounds	125 mL	Plastic (i.e. HPDE)	2	None	Nitric acid to pH ≤2. See method.	AA – cold vapor manual	245.1
						AA – cold vapor automater	245.2
Cyanide	1 L	Plastic	2	Ascorbic acid	Sodium hydroxide to pH 12. See method.	Titrimetric Spectrophotometric	335.2
						Colorimetric UV	335.3
Radiological	2 L	Plastic	2	None	None - mark samples not preserved	Gross alpha, gross beta, gamma isotopes, specific radionuclides	900 Series

Sample Type	Container Size	Container Type	No.	Dechlorinating Agent	Preservative	Analytical Technique	Reference Methods
CHEMISTRY - EXPANDED SCREEN (Exploratory Techniques)							
Unknown organics (volatile)	40 mL	Glass w / Teflon faced septa	5	None	None - mark samples not preserved	P&T-GC/MS	See Module 4
Unknown organics (general)	1 L	Amber Glass	4	None	None - mark samples not preserved	**Prep**: SPE, SPME, micro LLE, direct aqueous injection, headspace **Analysis**: GC/MS, GC, HPLC, LC-MS	See Module 4
Unknown inorganics	1 L	Plastic	2	None	None - mark samples not preserved	ICP-MS	See Module 4
Immunoassays	1 L	Amber Glass	2	Consult manufacturers instructions	Consult manufacturers instructions	Consult manufacturers instructions	None
PATHOGENS - EXPANDED SCREEN (Established and Exploratory Techniques)							
Pathogens - culture	100 mL	HDPE (plastic)	2	Thiosulfate	TBD	Per target pathogens	See Module 4
Pathogens - PCR	100 mL	HDPE (plastic)	2	Thiosulfate	TBD	Per target pathogens	See Module 4
BASELINE WATER QUALITY PARAMETERS (See Section 3.4)							
Water quality: bacteria	250 mL	Plastic	1	Thiosulfate	None	Fecal coliforms, E-coli,	Standard methods
Water quality: chemistry	1 L	Plastic	1	None	None - mark samples not preserved	Conductivity, pH, alkalinity, hardness, turbidity	Standard methods
Surrogates	1 L	Amber glass	2	None	None - mark samples not preserved	Total organic carbon, ultraviolet absorbance, color, chlorine demand	Standard methods
Toxicity	125 mL	Glass	2	Consult manufacturers instructions	Consult manufacturers instructions.	Rapid toxicity assay (several vendors)	None

3.4 Sample Collection Guidelines

3.4.1 Safety Guidelines

1. **Do not** enter the site to perform sampling until cleared. Hazardous materials response units may perform safety screening before allowing other responders to enter the site. *Note that field safety screening does **not** generally include testing for pathogens.*
2. **Do not** eat, drink, or smoke at the site.
3. **Do not** taste or smell the water samples.
4. **Do** use general personal protective equipment (PPE) such as splash-proof goggles, disposable gloves, proper footwear (i.e., no open toe or open heel shoes), a chemical resistant, disposable lab coat, and long pants. (*Note that this level of PPE is only intended to minimize incidental contact with the water or chemical reagents used during sample collection or field testing.*)
5. **Avoid** all skin contact with the water, and if incidental contact does occur, immediately flush the affected area with clean water brought to the site for that purpose.
6. Fill sampling containers **slowly** to avoid volatilization or aerosolization of contaminants.
7. **Minimize** the time that personnel are on the site and collecting samples.

3.4.2 Sampling Procedures

1. Pre-label sample containers with a waterproof marker. Information should include: analyte class (pathogen, chemical, or radionuclide), specific analyte (if sample is being collected for a specific target), sample identification number, utility name, location of sample collection, sample collection date and time, and sampler's initials.
2. Check for the presence of any in-line filters (e.g., home treatment devices) that might interfere with sampling. Remove such devices if present.
3. If the sample tap is the suspected point of contaminant introduction, collect swab samples from the tap ***before*** flushing the tap and collecting water samples.
4. Flush sample taps for a time sufficient to displace the water in connecting lines in order to obtain a sample that is representative of the water of interest. Keep the flow rate from the sample tap sufficiently low in order to avoid splashing and aerosolizing water droplets. Divert water to a drain if possible.
5. Carefully collect samples in the specified containers (see Section 3.3). If a reagent needs to be added to the sample, allow enough headspace in the container to add the proper amount of preservative. Cap then gently mix the contents to ensure that the reagent is properly mixed with the sample. Test the sample with a strip of pH paper to ensure preservation to the proper pH. Do not insert the pH paper into the sample container. Pour a small portion of the mixed sample into the container cap then pour from the cap onto the pH paper to verify
6. For chlorinated samples, VOCs should be collected into a secondary 8-oz. glass container (prepared with ascorbic acid - see footnote 1, Table 3.3). Gently mix the sample and transfer to 3, 40-ml VOA containers (triplicate). Fill the 40-ml container above the top to form a meniscus. Close the container with the Teflon side of the septa facing the water sample, gently invert the sample container several times, and verify that there are no air bubbles in the container. Once each container is tagged, the three 40-ml containers

should be inserted into a plastic whirlpack bag (provided) and sealed prior to sample storage.

7. Wipe the outside of the sealed containers with paper towel.
8. Attach custody seal to the sample container.
9. Place the sealed container into a rigid cooler and pack with frozen ice packs (preferred) or sealable freezer bags filled with ice.
10. Tag each sample and record all necessary information on "Sample Documentation" and "Chain of Custody" forms.
11. After all samples have been collected, preservative blanks and temperature blanks should be prepared and tagged. A preservative blank should be prepared for each preservative used during the sampling event. The preservative blank can be prepared by adding the appropriate amount of preservative to the preservative blank containers, and tagging the sample for the appropriate analysis (i.e., HNO3 preservative blank should be analyzed for metals). Additionally, a temperature blank container should be placed in each cooler containing samples.

3.4.3 Sample Holding

1. When samples are not in the possession of designated personnel, they should be secured (e.g., locked in a *secure area*) and only accessible by designated personnel. In the field, samples may need to be locked in a vehicle.
2. Samples should be chilled, but protected from freezing.
3. Samples should be held at the drinking water utility lab until shipped to a lab for analysis or until it is determined that they are not needed.
4. Samples that are held longer than the approved holding times for contaminant analysis may no longer be useful.

3.4.4 Sample Transport

1. Sample integrity and chain of custody must be maintained. All factors that might compromise sample integrity (e.g., storage containers, excessive transit time, temperature, pressure, physical disturbance, etc.) should be considered and appropriate measures taken to avoid compromising samples.
2. Sample packaging must be in compliance with shipping regulations.
3. Samples may be screened by law enforcement and/or ICs prior to sample transport to the laboratory.
4. Samples will be transported to the appropriate laboratory in coordination with law enforcement using appropriate air and ground assets.

3.5 Site Characterization Plan Template

INSTRUCTIONS

This form is intended to support the development of a customized site characterization plan developed in response to a specific water contamination threat. The incident commander and site characterization team leader should develop this plan jointly if possible. The completed form will be used to guide site characterization activities in the field; however, it may be necessary to revise the initial plan based on initial observations at the site. A form should be completed for each investigation site that will be characterized.

THREAT WARNING INFORMATION

Consult Module 2, Appendix 8.2 "Threat Evaluation Worksheet" for details about the threat.

INVESTIGATION SITE

Site Name: _____

Type of facility:

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Ground storage tank reservoir
- ☐ Elevated storage tank
- ☐ Finished water
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Additional Site Information: _____

_____

INITIAL HAZARD ASSESSMENT

Are there any indicators of an explosive hazard? ☐ Yes ☐ No

If "Yes," notify law enforcement and do not send a team to the site.

Initial hazard categorization

- ☐ Low hazard
- ☐ Chemical hazard
- ☐ Radiological hazard
- ☐ Biological hazard

If the initial hazard assessment indicates a chemical, radiological, or biological hazard (as described in Module 3, Section 4.1.3), then only teams trained to deal with such hazards should be sent to the site.

SITE CHARACTERIZATION TEAM

Name & Affiliation of Site Characterization Team Leader:

_____

Drinking water utility staff:

- ☐ Water quality specialist Name: _____
- ☐ Security specialist Name: _____
- ☐ Operations specialist Name: _____
- ☐ Other _____ Name: _____

Representatives from other agencies:

- ☐ Local law enforcement ☐ Fire department ☐ HazMat
- ☐ US EPA ☐ FBI ☐ Other

COMMUNICATION PROCEDURES

Mode of communication:

- ☐ Phone ☐ 2-way radio ☐ Digital
- ☐ Facsimile ☐ Other _____

Reporting events:

- ☐ Upon arrival at site ☐ During approach ☐ Site entry
- ☐ After site evaluation ☐ After field testing ☐ Site exit
- ☐ Other _____

FIELD SCREENING CHECKLIST

8	Parameter[1]	Screen[2]	Meter/Kit ID[3]	Check Date[4]	Reference Value[5]
	Radiation	Both			
	Chlorine residual	Water			
	pH / conductivity	Water			
	Cyanide	Water			
	Volatile chemicals	Safety			
	Chemical weapons	Both			
	Biotoxins	Water			
	Pathogens	Water			

1. List the parameters that will be evaluated as part of field screening (examples are listed).
2. Screening may be conducted for safety, rapid water testing, or both.
3. Report the unique identifier for the meter or kit used during screening.
4. Report date of last calibration, last equipment check, or expiration date as appropriate.
5. List any reference value that would trigger a particular action, such as exiting the site.

SAMPLING CHECKLIST

8	Analyte[1]	No. Samples	Sample Preservation[2]
	Standard VOCs		
	Semi-volatiles		
	Quartenary nitrogen compounds		
	Cyanide		
	Carbamate pesticides		
	Metals/elements		
	Organometallic compounds		
	Cyanide		
	Radionuclides		
	Non-target VOCs		
	Non-target organic compounds		
	Non-target inorganic compounds		
	Immunoassays		
	Pathogens – culture		
	Pathogens – PCR		
	Water quality – bacteria		
	Water quality – chemistry		

1. List the parameters that will be sampled during site characterization (examples are listed).
2. List preservatives and dechlorinating agents and indicate if they are to be added in the field.

EQUIPMENT CHECKLIST

- ☐ Completed Site Characterization Plan
- ☐ Emergency Water Sampling Kit (Table 3-1)
- ☐ Reagents (if stored separately)
- ☐ Laboratory grade water (5 gal)
- ☐ Special equipment for the specific site
- ☐ Additional documentation
- ☐ Field Testing Kit (Table 3-3)
- ☐ Bags of ice or freezer packs
- ☐ Rinse water (20 liters)
- ☐ Disposable camera
- ☐ Other _____

SAMPLE HANDLING INSTRUCTIONS

Sample delivery:

- ☐ Return samples to water utility
- ☐ Ship samples to specified location
- ☐ Deliver samples to specified recipient (e.g., laboratory, law enforcement, shipping co., etc.)

Name of recipient: _____

Phone No.: _____ Fax No.: _____

Delivery address: _____

_____

Sample storage and security:

Describe any special precautions or instructions related to sample storage and security:

_____

_____

_____

SIGNOFF

Incident Commander (or designee responsible for developing Site Characterization Plan):

Print name _____

Signature _____ Date/Time: _____

Site Characterization Team Leader:

Print name _____

Signature _____ Date/Time: _____

3.6 Site Characterization Report Form

INSTRUCTIONS

Members of the site characterization team can use this form to record their observations at the investigation site. It also serves as a checklist for notifying incident command at key points during the characterization. Additional checklists are included in this form for sample collection and exiting the site. The completed form can also be used as a component of the site characterization report. A form should be completed for each investigation site that is characterized

GENERAL INFORMATION

Date: _____ **Time arrived investigation at site:** _____

Name of Site Characterization Team Leader: _____

Phone No.: _____ **Fax No.:** _____

LOCATION OF INVESTIGATION SITE

Site Name: _____

Type of facility:

- ☐ Source water
- ☐ Treatment plant
- ☐ Pump station
- ☐ Finished water reservoir
- ☐ Elevated storage tank
- ☐ Ground storage tank
- ☐ Distribution main
- ☐ Hydrant
- ☐ Service connection
- ☐ Other _____

Address: _____

_____

Weather Conditions at Site: _____

_____

Additional Site Information: _____

_____

APPROACH TO SITE

Time of Approach to Site: _____

Initial Field Safety Screening (as listed in the "Site Characterization Plan"):

☐ None ☐ Radiation ☐ Volatile chemicals
☐ HAZCAT ☐ Chemical weapons ☐ Biological agents
☐ Other _____

Report results of field safety screening in Section 3.7 "Field Testing Results Form."
If any field safety screening result is above the corresponding reference value, immediately notify incident command and do not proceed further into the site.

Initial Observation and Assessment of Immediate Hazards

☐ Unauthorized individuals present at the site
☐ Fire or other obvious hazard
☐ Signs of a potential explosive hazard (e.g., devices with exposed wires)
☐ Signs of a potential chemical hazard (e.g., dead animals, unusual fogs, unusual odors)
☐ Unusual and unexplained equipment at the site
☐ Other signs of immediate hazard _____

If there are any indicators of immediate hazard, immediately notify incident command and do not proceed further into the site.

Report initial observations and results to incident commander.
Approval granted to proceed further into the site? ☐ Yes ☐ No

SITE INVESTIGATION

Time of Entry to Site: _____

Repeat Field Safety Screening

☐ None ☐ Radiation ☐ Volatile chemicals
☐ HAZCAT ☐ Chemical weapons ☐ Biological agents
☐ Other _____

Report results of field safety screening in Section 3.7 "Field Testing Results Form."
If any field safety screening result is above the corresponding reference value, immediately notify incident command and do not proceed further into the site.

Signs of Hazard:

☐ None ☐ Unexplained dead animals
☐ Unexplained dead or stressed vegetation ☐ Unexplained clouds or vapors
☐ Unexplained liquids ☐ Other _____

Describe signs of hazard: _____
_____
_____

Unexplained or Unusual Odors:

☐ None ☐ Pungent ☐ Irritating
☐ Sulfur ☐ Skunky ☐ Bitter almond
☐ Sweet/Fruity ☐ New mown hay ☐ Other _____

Describe unusual odor: _____
_____
_____

Unusual Vehicles Found at the Site:

☐ Car/sedan ☐ SUV ☐ Pickup truck
☐ Flatbed truck ☐ Construction vehicle ☐ None
☐ Other _____

Describe vehicles (including make/model/year/color, license plate #, and logos or markings): _____
_____
_____
_____
_____

Signs of Tampering:

☐ None ☐ Cut locks/fences
☐ Open/damaged gates, doors, or windows ☐ Open/damaged access hatches
☐ Missing/damaged equipment ☐ Facility in disarray
☐ Other _____

Signs of sequential intrusion (e.g., locks removed from a gate and hatch)?
☐ Yes ☐ No

Describe signs of tampering: _____
_____
_____
_____

Unusual Equipment:

☐ None ☐ Discarded PPE (e.g., gloves, masks)
☐ Tools (e.g., wrenches, bolt cutters) ☐ Hardware (e.g., valves, pipe)
☐ Lab equipment (e.g., beakers, tubing) ☐ Pumping equipment
☐ Other _____

Describe equipment: _____
_____
_____
_____

Unusual Containers:

Type of container:

☐ None ☐ Drum/Barrel ☐ Bottle/Jar
☐ Plastic bag ☐ Box/Bin ☐ Pressurized cylinder
☐ Test Tube ☐ Bulk container ☐ Other _____
_____

Condition of container:

☐ Opened ☐ New ☐ Damaged/leaking
☐ Unopened ☐ Old ☐ Intact/dry

Size of container: _____

Describe labeling on container: _____
_____

Describe visible contents of container: _____
_____

Rapid Field Testing of the Water

☐ None ☐ Residual disinfectant ☐ pH / conductivity
☐ Cyanide ☐ Radiation ☐ VOCs and SVOCs
☐ Pesticides ☐ Biotoxins ☐ General toxicity
☐ Other _____

Report results of rapid field testing of the water in Section 3.7 "Field Testing Results Form."
If any field test result is above the corresponding reference value, immediately notify incident command and wait for instruction regarding how to proceed.

Report findings of site investigation to incident commander.
Approval granted to proceed with sample collection? ☐ Yes ☐ No

SAMPLING

Time Sampling was Initiated / Completed: _____ /_____

Implement Sampling Procedures Appropriate for the Hazard Conditions at the Site:

☐ Low hazard ☐ Chemical hazard
☐ Radiological hazard ☐ Biological hazard

If the site is characterized as a chemical, radiological, or biological hazard, then special sampling and safety procedures should be followed.

Safety Checklist:

- ☐ **Do not** eat, drink, or smoke at the site.
- ☐ **Do not** taste or smell the water samples.
- ☐ **Do** use the general PPE included in the emergency water sampling kit.
- ☐ **Avoid** all contact with the water, and flush immediately with clean water in the case of contact.
- ☐ **Slowly fill** sample bottles to avoid volatilization and aerosolization.
- ☐ **Minimize** the time that personnel are on site and collecting samples.

General Sampling Guidelines:

- ☐ Properly label each sample bottle.
- ☐ Carefully flush sample taps prior to sample collection, if applicable.
- ☐ Collect samples according to method requirements (e.g., w/o headspace for VOCs).
- ☐ Add preservatives or dechlorinating agents as specified.
- ☐ Carefully close sample containers and verify that they don't leak.
- ☐ Wipe the outside of sample containers with a mild bleach solution if needed.
- ☐ Place sample containers into a sealable plastic bag.
- ☐ Place samples into an appropriate, rigid shipping container.
- ☐ Pack container with frozen ice packs.
- ☐ Complete "Sample Documentation Form" (Section 3.8).
- ☐ Complete "Chain of Custody Form" (Section 3.9).
- ☐ Secure shipping container with custody tape.
- ☐ Comply with any other sample security provisions required by participating agencies.

EXITING THE SITE

Time of Site Exit: _____

Site Exit Checklist

- ☐ Verify that hatches, locks, etc. are properly secured.
- ☐ Remove all samples, equipment, and materials from the site.
- ☐ Verify that all samples are in the cooler and properly seal the cooler.
- ☐ Remove all PPE at site perimeter.
- ☐ Place disposable PPE and other trash into a heavy-duty plastic trash bag.
- ☐ Verify that the perimeter has been properly secured before leaving the site.
- ☐ Ensure that all documentation has been completed before leaving the site perimeter.
- ☐ Comply with any site control measures required by participating agencies.
- ☐ Contact incident commander and inform them that the team is leaving the site.

SIGNOFF

Site Characterization Team Leader:

Print name _____

Signature _____ Date/Time: _____

3.7 Field Testing Results Form

Date of Field Testing:		**Site Name:**		**Field Tester:**		**Phone No.**	
Parameter	**Units**	**Screen[1]**	**Meter/Kit ID[2]**	**Testing Location[3]**	**Testing Time[4]**	**Results[5]**	**Ref. Value[6]**

1: Screening may be conducted for safety, rapid water testing, or both.
2: Report the unique identifier for the meter or kit used during screening.
3: Report the specific location where the field testing was conducted.
4: Report the specific time at which the test was performed.
5: Results of field testing should include replicate analysis where appropriate.
6. Results should be compared with a reference value, if available, to determine whether or not the levels detected pose a hazard.

3.8 Sample Documentation Form

Collection Date:		**Site Name:**		**Sampler:**	**Phone No.**	
Sample ID	**No. Bottles**	**Sampling Time**	**Sampling Location**	**Sample Description**	**Analysis**	**Sample Additives[1]**

1: Report preservatives, dechlorinating agents, acid/base for pH adjustment, and any other sample additives.

3.9 Chain of Custody Form

Site Name:		**Sampler:**	
Sampler Phone No.:		**Signature:**	
Sample ID	**Collection Date**	**No. Bottles**	**Analysis**

Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**
Relinquished by:	**Received by:**	**Date/time:**

Dispatched by:	**Date/time:**	**Received for Laboratory by:**	**Date/time:**

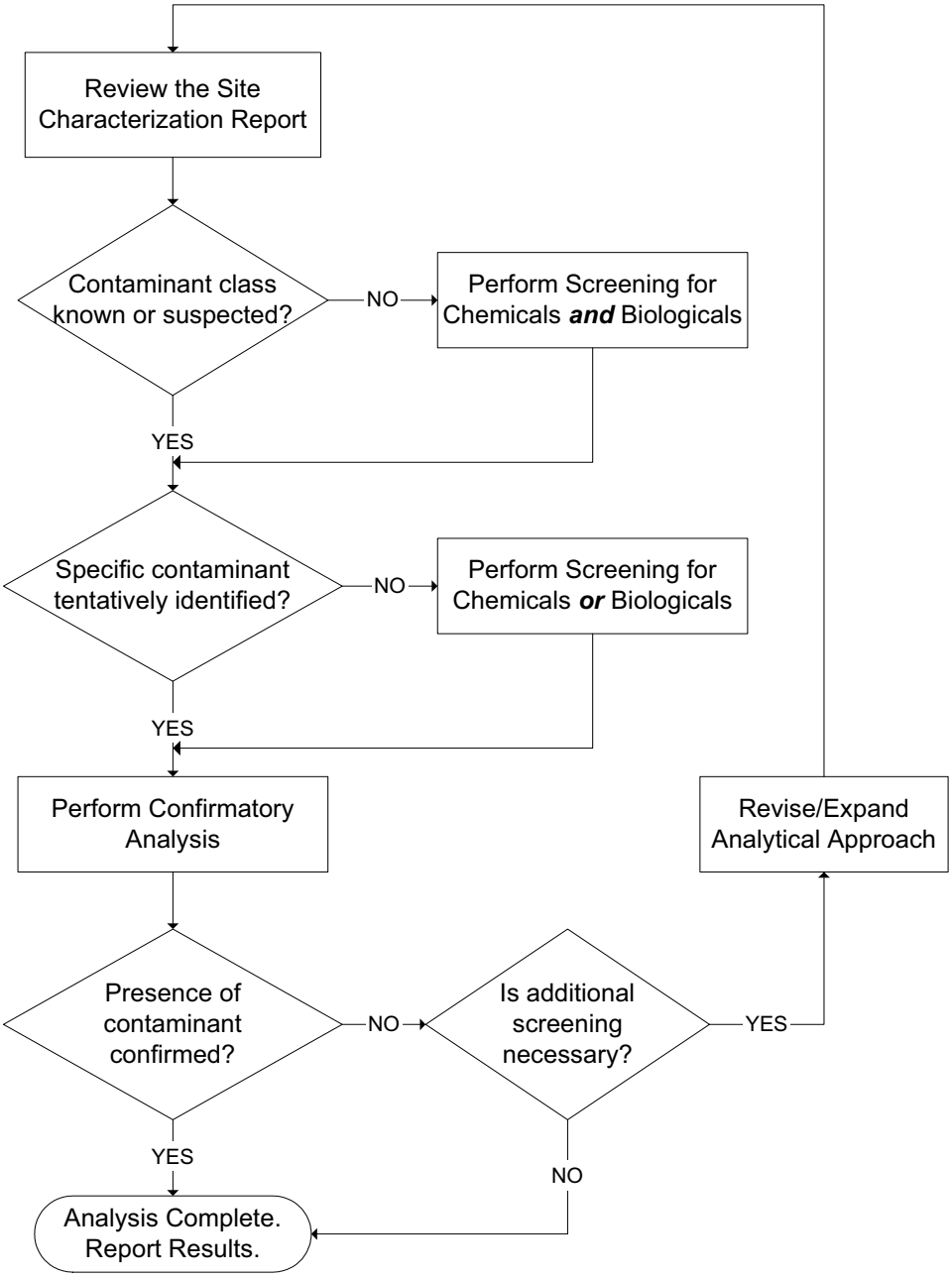
Method of Sample Transport:		
Shipper:	**Phone No.:**	**Tracking No.:**

4 Sample Analysis

4.1 Laboratory Contact List

Analysis	Laboratory	Physical Address	Contact Person	Phone
Pathogens				
Chemical				
Chemical				
Radiological				
CW Agents				

4.2 General Approach for Analysis of Unknowns in Water



4.3 General Classes of Chemicals, Analyte Groups, and Example Contaminants

Chemical types	Analytical Group	Example Contaminants*
Organic	Volatiles	Acetone, acrylonitrile, chloroform, methyl *t*-butyl ether, tetrachloroethene, toluene,
	Semivolatiles	Organophosphates (e.g., malathion, mevinphos, dichlorvos, etc.), cyanazine, chlorinated insecticides, chlordane, pentachlorophenol
	Non-volatiles	Sodium trifluroacetates, surfactants
	Carbamate compounds	Aldicarb, carbofuran, oxamyl
	Quaternary nitrogen compounds	Diquat, paraquat
	Pharmaceuticals	Nicotine, illicit drugs
Inorganic	Trace metals	Mercury, lead, cobalt
	Nonmetals	Arsenic salts
	Organometallics	Organomercury compounds
Cyanides	Cyanides	Cyanide salts, cyanogen chloride
Radionuclides	Radiologicals	Cesium-137, Cobalt-60, Strontium-92
CW Agents	Schedule 1 only	(e.g., VX, sarin, nitrogen and sulfur mustards, Lewsites)

* Not every contaminant in a particular analytical group is listed in this column.

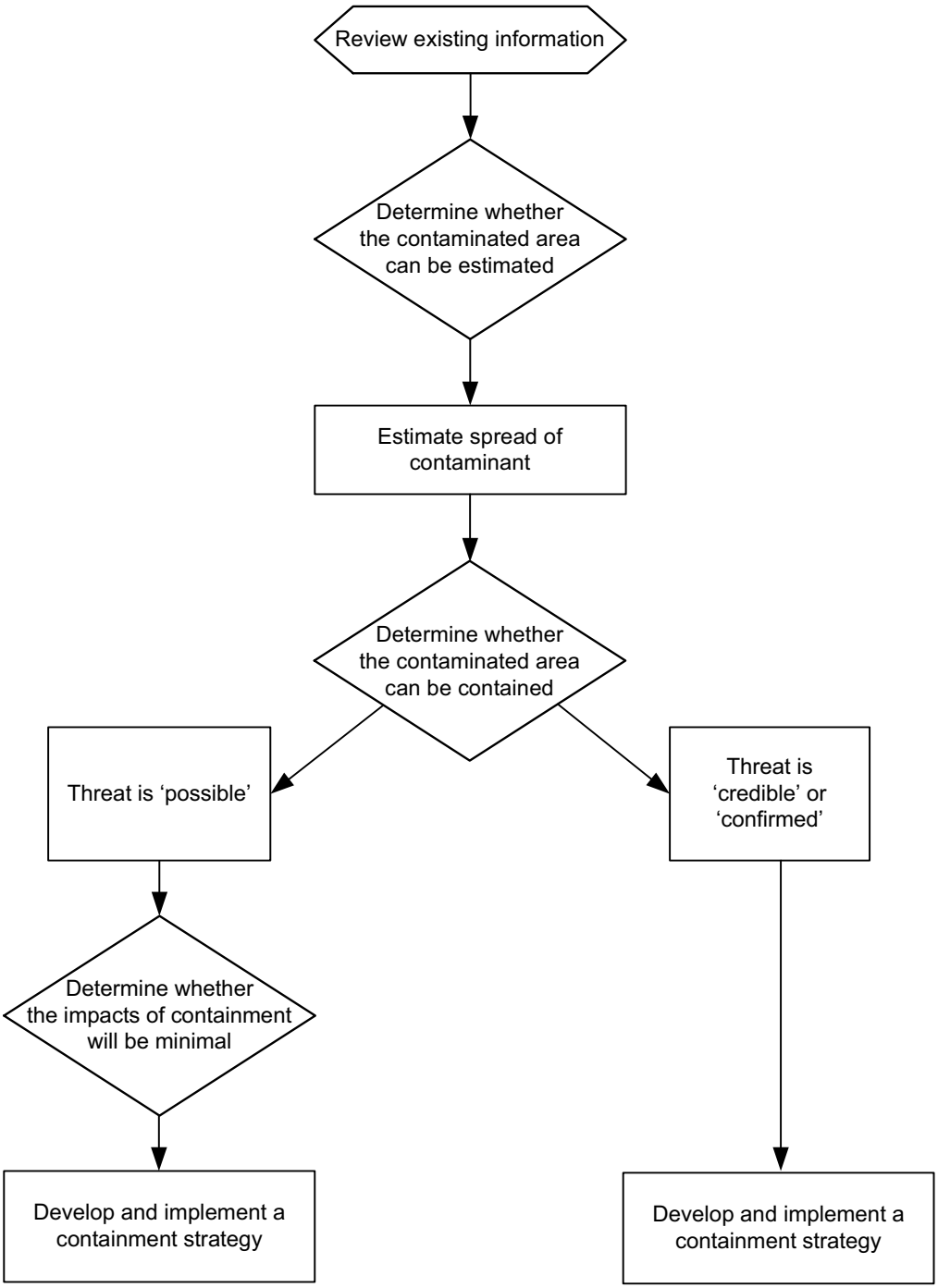
4.4 General Classes of Pathogens, Specific Organisms, and Select Agent Status

Pathogen general class	Organism	Select Agent*
Bacteria (non-spore forming)	*Brucella* spp.	Yes
	Burkholderia pseudomallerei	Yes
	Campylobacter spp.	
	E. coli 0157:H7	
	Francisella tularensis	Yes
	Salmonella spp.	
	Shigella spp.	
	Vibrio cholerae	
	Yersinia pestis	Yes
Bacteria (spore forming)	*Bacillus anthracis*	Yes
	Clostridium botulinum A	Yes
Bacteria (Rickettsia)	*Coxiella burnetti*	Yes
Protozoa	*Cryptosporidium parvum*	
	Entamoeba histolytica	
	Giardia intestinalis	
	Toxoplasma gondii	
Viruses	Enteroviruses	
	Hepatitis A	
	Hepatitis E	
	Noroviruses	
	Rotavirus	
	Variola	Yes
	VEE	Yes
	VHF	Yes

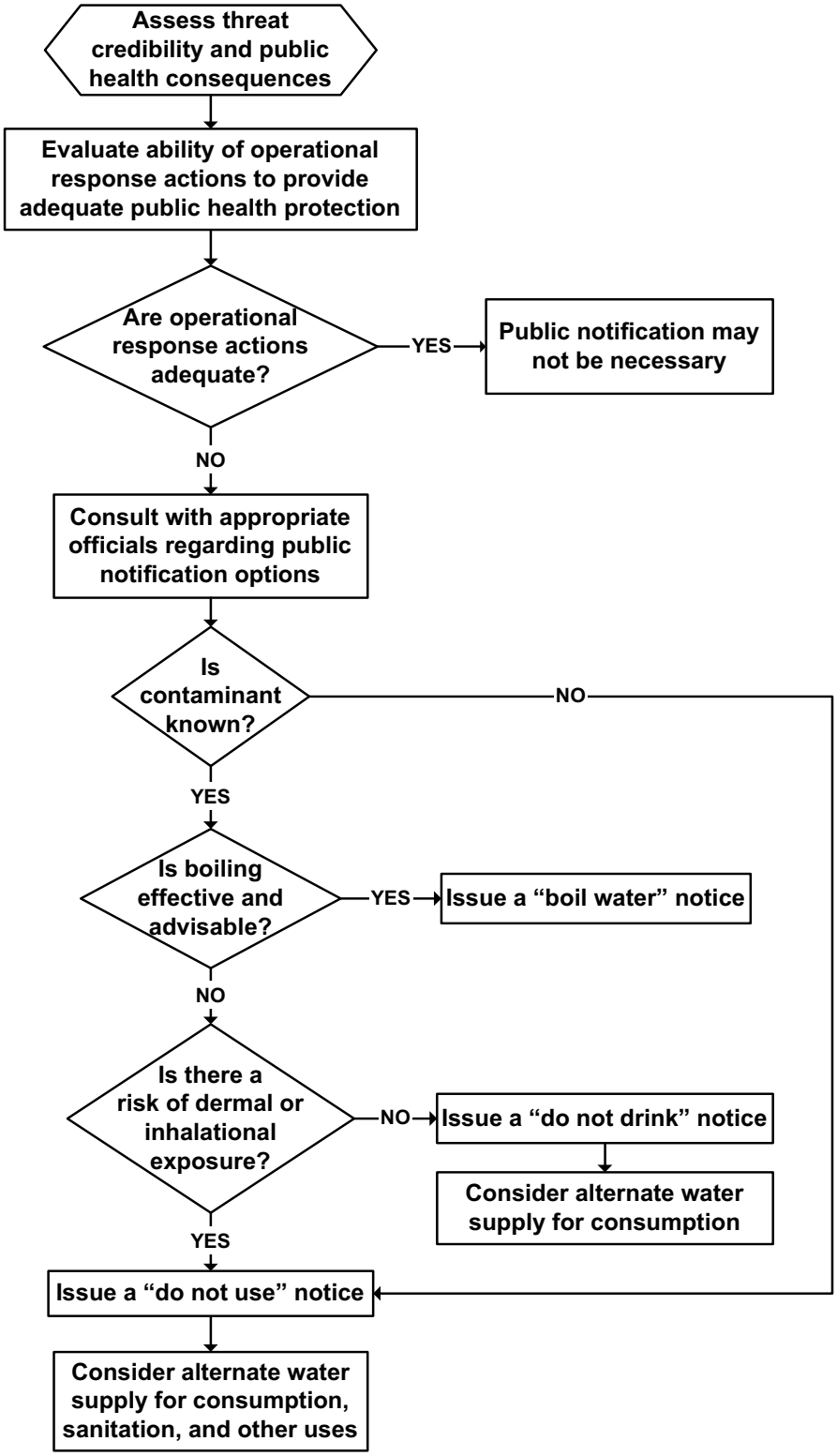
* See http://www.cdc.gov/od/sap/docs/salist.pdf

5 Response Actions

5.1 Decision Tree for Containment Options



5.2 Decision Tree for Public Notification



5.3 Contaminant Characterization and Transport Worksheet

INSTRUCTIONS

The purpose of this worksheet is to help organize information that will lead to the identification of the contaminant to facilitate decisions on appropriate operational responses and provide more accurate information for public communication/notification. Contaminant identification will most likely first be a presumptive identification followed by more lengthy procedures to verify the identity of the contaminant. While validated analytical results are typically the most reliable means of contaminant identification, other information collected during the ***threat evaluation*** *and* ***site characterization*** *may provide valuable insight regarding the identity of the contaminant.*

SITE CHARACTERIZATION/THREAT EVALUATION SUMMARY

Describe the contaminant's odor, if applicable. _____

Describe the *reported* taste of the contaminant, if applicable. _____
Caution: Do NOT taste the water.

What was the physical form of the contaminant?

☐ Solid ☐ Liquid ☐ Gas
☐ Slurry ☐ Powder ☐ Granules
☐ Other _____

What color was the contaminant? _____

Summarize additional information obtained during site characterization/threat warning that is relevant to contaminant identification. _____
_____
_____
_____

Summarize the on-line monitoring data, consumer complaints, or witness accounts that are relevant to contaminant identification. _____
_____
_____
_____

Field Analysis Summary

Summarize the results of the field analysis for the following parameters:

Radiation _____
Chlorine residual _____
pH, conductivity _____
Cyanide _____
Volatile chemicals _____
Chemical weapons _____
Biotoxins _____
Pathogens _____
Other _____

Public Health Information

Have death or disease in the population been reported? ☐ Yes ☐ No ☐ Unknown

Type/symptoms _____
Is there information on unusual sales of pharmaceutical supplies (e.g., diarrhea medication)?_____
Number of people affected _____
Number of fatalities _____
Location/area affected _____

Was an epidemiological investigation conducted? ☐ Yes ☐ No ☐ Unknown
Results _____

Was a clinical investigation conducted? ☐ Yes ☐ No ☐ Unknown
Results _____

Is the contaminant acutely toxic and what are the acute effects? ☐ Yes ☐ No ☐ Unknown
Describe _____

LABORATORY ANALYSIS SUMMARY

Results of analysis _____

Reporting units _____

Analytical method _____

Minimum reporting level _____

Precision (relative standard deviation) _____

QA/QC (e.g., recovery of matrix spikes, standard checks, etc.) _____

Summarize additional information obtained during laboratory analysis that is relevant to contaminant identification.

_____
_____
_____

CONTAMINANT CHARACTERISTICS

What is the class of the contaminant?
☐ Biological ☐ Chemical ☐ Radiological
☐ Unknown _____

Can any conclusions regarding the contaminant properties be made? (Place an 'X' in the appropriate column)

	Yes	No	Unk	Comment/Additional Information
Is the contaminant susceptible to disinfection or chemical oxidation?				
Does the contaminant hydrolyze into less toxic products?				
Does the contaminant hydrolyze into more toxic products?				
What are pKa values for chemicals?				
Is the contaminant water soluble?				
Does the contaminant have a discernable taste, odor, or color?				
Is the contaminant volatile or semi-volatile?				
Does the contaminant impact the pH?				
Does the contaminant impact conductivity?				
Does the contaminant impact other water quality parameters?				
Does the contaminant react with certain disinfectants (i.e., chlorine, chloramines, etc.)?				
What is the contaminant's half life?				

Contaminant Public Health Effect Information

What are the primary routes of exposure?
☐ Ingestion ☐ Inhalation ☐ Dermal Contact
☐ Unknown _____

What are the acute health effects for the exposure routes identified? _____

What is the contaminant's LD_{50}/ID_{50}? _____

What is the length of time to first onset of symptoms after exposure? _____

What are the chronic health effects associated with exposure to the contaminant? _____

Does the contaminant have a method of secondary transmission?
☐ Yes ☐ No ☐ Unknown
Describe _____

Is an approach available to prevent undesirable health effects from the contaminant?
☐ Yes ☐ No ☐ Unknown
Describe _____

Are there treatments available for individuals exposed to the contaminant?
☐ Yes ☐ No ☐ Unknown
Describe _____

Are health standards for the contaminant available?
☐ Yes ☐ No ☐ Unknown
Describe _____

By which exposure route(s)?
☐ Ingestion ☐ Inhalation
☐ Dermal ☐ Ocular

List the levels for each exposure route.

_____

_____

Contaminant Treatment Information

Treatment Types	**Could be used to treat the contaminant?**	**Degradation products formed as a consequence of treatment**	**Rating of effectiveness (poor, fair, good) of percent effectiveness**
Lime softening	☐ Yes ☐ No		
Reverse osmosis	☐ Yes ☐ No		
Standard chlorination	☐ Yes ☐ No		
Enhanced chlorination	☐ Yes ☐ No		
Standard filtration	☐ Yes ☐ No		
Enhanced filtration	☐ Yes ☐ No		
Membrane filtration	☐ Yes ☐ No		
Nanofiltration	☐ Yes ☐ No		
Electrodialysis	☐ Yes ☐ No		
Cation exchange resin	☐ Yes ☐ No		
Anion exchange resin	☐ Yes ☐ No		
Activated alumina	☐ Yes ☐ No		
Chloramine	☐ Yes ☐ No		
Chlorine dioxide	☐ Yes ☐ No		
Standard UV	☐ Yes ☐ No		
Enhanced UV	☐ Yes ☐ No		
Standard ozone	☐ Yes ☐ No		
Enhanced ozone	☐ Yes ☐ No		
Standard GAC	☐ Yes ☐ No		
Enhanced GAC	☐ Yes ☐ No		
Standard air stripping	☐ Yes ☐ No		
Enhanced air stripping	☐ Yes ☐ No		
Other Methods	☐ Yes ☐ No		

Access to contaminant information (effects and properties)

In-house information
Contact/phone no. _____
Internal database _____

Public Health officials
Contact/phone no. _____
Web site/database _____

US EPA Water Contaminant Information Tool
Web site/access code_____

- US EPA water contaminant information tool (WCIT).
- US EPA's List of Drinking Water Contaminants & MCLs: http://www.epa.gov/safewater/mcl.html#mcls.
- Agency for Toxic Substances and Disease Registry (ATSDR): www.atsdr.cdc.gov.
- CDC Emergency Preparedness and Response: www.bt.cdc.gov.
- Recognizing Waterborne Disease and the Health Effects of Water Pollution: A Physician On-line Reference Guide: www.WaterHealthConnection.org.
- Physician Preparedness for Acts of Water Terrorism: www.waterhealthconnection.org/bt/index.asp.
- Registry of Toxic Effects of Chemical Substances (RTECS): www.cdc.gov/niosh/rtecs.html.
- Risk Assessment Information System (RAIS), which contains information taken from US EPA's Integrated Risk Information System (IRIS), the *Health Effects Assessment Summary Tables* (HEAST-rad HEAST-nonrad), US EPA Peer Reviewed Toxicity Values (PRTVs) Database, and other information sources: http://risk.lsd.ornl.gov/index.shtml.
- United States Army Medical Research Institute of Infectious Diseases (USAMRIID) Medical Management of Biological Casualties Handbook: http://www.usamriid.army.mil/education/bluebook.html.
- WHO: www.who.int/search/en/.
- WHO's "Public health response to biological and chemical weapons:" www.who.int/csr/delibepidemics/biochemguide/en/index.html.

CONTAMINANT TRANSPORT

Summarize what is known regarding the location of contaminant introduction.

_____
_____
_____

How much material was used _____(lbs., tons, gal, etc.)

How was it added? ☐ Single dose ☐ Over time ☐ Unknown

Time period of suspected contaminant introduction. _____

Elapsed time. _____

Method of estimating the spread.
☐ Manual calculations ☐ Hydraulic model ☐ Water flow analysis
☐ GIS ☐ Field analysis ☐ Areas of customer complaints
☐ Areas of people with health-related symptoms
☐ Other _____

Estimate the contaminated area. _____

Estimate the population affected._____

Identify any customers with special needs that are within the affected area.

- ☐ Critical Care Facilities
  - ☐ Hospitals
  - ☐ Clinics
  - ☐ Nursing Homes
  - ☐ Dialysis Centers
  - ☐ Other _____
- ☐ Schools
- ☐ Day Care Facilities
- ☐ Businesses
  - ☐ Food and Beverage Manufacturers
  - ☐ Commercial Ice Manufacturers
  - ☐ Restaurants
  - ☐ Agricultural Operations
  - ☐ Power Generation Facilities
  - ☐ Other _____

SIGNOFF

Name of person completing form

Print name _____

Signature _____ Date/Time: _____

5.4 Public Health Response Action Worksheet

INSTRUCTIONS

The purpose of this form is to help organize information to aid in the evaluation of containment options and public notification options. The objectives of public health response actions (operational and public notification) are to prevent or limit public exposure to potentially contaminated water by either restricting further propagation of the contaminant through the distribution system or restricting use of the water through public notification. This worksheet assumes that the "Contaminant Characterization and Transport Worksheet" in Section 5.3 has been completed to the extent possible.

ASSESSMENT OF PUBLIC HEALTH IMPACT

Identity of the contaminant ☐ Suspected ☐ Known ☐ Unknown

Describe _____

Contaminant properties (if known):

Toxic or infectious dose (LD_{50}/ID_{50}): _____

Route of exposure:

☐ Ingestion ☐ Inhalation ☐ Dermal Contact

☐ Other _____

Symptoms of exposure to high dose: _____

Symptoms of exposure to low dose: _____

Other: _____

EVALUATION OF CONTAINMENT OPTIONS

Describe the location and extent of the contaminated area. _____

_____

_____

Containment options

☐ Valve closures ☐ Reverse flow conditions ☐ By-pass

☐ Isolate zone(s)

☐ Other _____

Critical equipment within contaminated area

☐ System equipment ☐ Zones ☐ Pump stations

☐ Hydrants ☐ Other _____

Customers with special needs within contaminated area

☐ Critical Care Facilities

- ☐ Hospitals
- ☐ Clinics
- ☐ Nursing Homes
- ☐ Dialysis Centers
- ☐ Other _____

☐ Schools

☐ Businesses

- ☐ Food and Beverage Manufacturers
- ☐ Commercial Ice Manufacturers
- ☐ Restaurants
- ☐ Agricultural Operations
- ☐ Power Generation Facilities
- ☐ Other _____

Effectiveness of containment options

☐ Complete contaminant isolation ☐ Reduction in spread of contaminant
☐ Unknown ☐ Other _____

Is containment expected to provide adequate public health protection?
☐ Yes ☐ No ☐ Unknown

Timeline for implementation of containment options

Containment procedures to begin: _____
Containment procedures to end: _____

EVALUATION OF PUBLIC NOTIFICATION OPTIONS

Is public notification necessary? ☐ Yes ☐ No

Collaboration Agencies (identified in Public Health Response Plan and Utility's ERP)

☐ Public health agencies ☐ Police departments ☐ Fire departments
☐ Hospitals/clinics ☐ Laboratories ☐ Drinking water primacy agency
☐ Regional Poison Control Center
☐ Other _____

Type of notification (Follow steps shown)

Is the contaminant known? ☐ Yes ☐ No
If no, issue a " Do Not Use" notice.
- If yes, is boiling effective and advisable? ☐ Yes ☐ No ☐ Unknown
If yes, issue a "Boil Water" notice.
- - If no or unknown, is there a risk of dermal or inhalation exposure? ☐ Yes ☐ No ☐ Unknown
If no, issue a "Do Not Drink" notice.
If yes or unknown, issue a " Do Not Use" notice.

Content of public notification

☐ Has the contamination incident been confirmed? ☐ Yes ☐ No
☐ Is the contaminant known? ☐ Yes ☐ No
☐ If yes, identity of the contaminant _____
☐ Characteristics of the contaminant _____
☐ Restrictions on use _____
☐ Ingestion exposure ☐ Inhalation exposure ☐ Dermal exposure
☐ Exposure symptoms _____
☐ Medical treatments _____
☐ Transmission mode (if biological) _____
☐ Duration of restriction _____
☐ Alternate water supply _____
☐ Additional instructions to consumers _____
☐ Other information about the incident _____
☐ Other _____

Notification to customers with special needs

☐ Critical Care Facilities
- ☐ Hospitals
- ☐ Clinics
- ☐ Nursing Homes
- ☐ Dialysis Centers
- ☐ Other _____

☐ Schools

☐ Businesses
- ☐ Food and Beverage Manufacturers
- ☐ Commercial Ice Manufacturers
- ☐ Restaurants
- ☐ Agricultural Operations
- ☐ Power Generation Facilities
- ☐ Other _____

Are there subpopulations that will be affected at a greater rate than general population?

☐ Yes ☐ No ☐ Unknown

Describe _____

Notification to consecutive system.

☐ Yes ☐ No ☐ Not Applicable

Method of dissemination

- ☐ Broadcast media (radio and television)
- ☐ Government access channels
- ☐ Web site
- ☐ Listserve email
- ☐ Newspaper
- ☐ Letters by mail
- ☐ Newsletters (water utility or partner organizations)
- ☐ Phone banks
- ☐ Broadcast phone messages
- ☐ Broadcast faxes
- ☐ Posting in conspicuous locations
- ☐ Mass distribution through partners
- ☐ Hand delivery
- ☐ Door-to-door canvassing
- ☐ Town hall meetings
- ☐ Conference calls
- ☐ Other _____

Notification/restriction timeline

Notification/restriction to begin: _____

Notification/restriction to end: _____

ALTERNATE WATER SUPPLY NEEDS

Is an alternate water supply needed?

- ☐ Drinking water
- ☐ Fire fighting
- ☐ Other _____

Where can customers obtain the alternate water supply?

- ☐ Bottled water provided by local government agencies
- ☐ Bottled water provided by local retailers
- ☐ Bulk water provided by certified water haulers
- ☐ Bulk water transported or provided by military assets
- ☐ Bulk water providing by neighboring water utilities
- ☐ Water treated at plant and hauled to distribution centers (i.e., in the case of distribution system contamination)
- ☐ Other _____

What customers with special needs should be notified of the alternate water supply availability?

- ☐ Critical Care Facilities
  - ☐ Hospitals
  - ☐ Clinics
  - ☐ Nursing Homes
  - ☐ Dialysis Centers
  - ☐ Other _____
- ☐ Schools
- ☐ Businesses
  - ☐ Food and Beverage Manufacturers
  - ☐ Commercial Ice Manufacturers
  - ☐ Restaurants
  - ☐ Agricultural Operations
  - ☐ Power Generation Facilities
  - ☐ Other _____

SIGNOFF

Name of person completing form

Print name _____

Signature _____ Date/Time: _____

6 Appendices

6.1 Critical System Information Checklist

- Population Served and Service Connections
- Distribution Network Map (including pressure zones)
- Pressure Zone Map
- Treatment Process Flow Diagram
- Chlorination Stations (location and quantity of chlorine on site)
- Chemical Handling and/or Storage Facilities and Release Impact Analysis
- Booster Pump Stations (location, capacity, and power requirements)
- Supervisory Control and Data Acquisition systems
- Site Staffing Rosters and Employee's Duties and Responsibilities
- Vulnerability Assessments
- Backup Equipment and Power Generation

6.2 Information Resources

- Agency for Toxic Substances and Disease Registry (ATSDR): www.atsdr.cdc.gov.
- AOAC. 2003b. "Rapid Test Kits Test Kit Database" http://www.aoac.org/testkits/TKDATA2.HTM.
- CDC Emergency Preparedness and Response: www.bt.cdc.gov.
- CDC. 2003f. "List of Select Biological Agents" http://www.cdc.gov/od/sap/docs/salist.pdf.
- CWC. 2003b. "The Chemical Weapons Convention – A Quick Guide, CWC-002" http://www.cwc.gov/Industry_Outreach/Publications/002/cwc-b0001_html.
- FEMA, Hazardous Materials Guide for First Responders. http://www.usfa.fema.gov/fire-service/hmgfr3.cfm
- Physician Preparedness for Acts of Water Terrorism: www.waterhealthconnection.org/bt/index.asp.
- Recognizing Waterborne Disease and the Health Effects of Water Pollution: A Physician On-line Reference Guide: www.waterhealthconnection.org.
- Registry of Toxic Effects of Chemical Substances (RTECS): www.cdc.gov/niosh/rtecs.html.
- Risk Assessment Information System (RAIS), which contains information taken from the US EPA Integrated Risk Information System (IRIS), the *Health Effects Assessment Summary Tables* (HEAST-rad HEAST-nonrad), US EPA Peer Reviewed Toxicity Values (PRTVs) Database, and other information sources: http://risk.lsd.ornl.gov/index.shtml.
- US Army Medical Research Institute of Infectious Diseases (USAMRIID) Medical Management of Biological Casualties Handbook: http://www.usamriid.army.mil/education/bluebook.html.
- US Army. 2002. "Toxic Chemical Agent Safety Standards" http://www.usapa.army.mil/pdffiles/p385_61.pdf.
- US Coast Guard. 2001. "Chemical Hazards Response Information System" http://www.chrismanual.com.
- US EPA's List of Drinking Water Contaminants & Maximum Contaminant Levels (MCLs): http://www.epa.gov/safewater/mcl.html#mcls.
- US EPA. 2000. "EPA Radiological Emergency Response Plan" http://www.epa.gov/radiation/rert/docs/rerp-1-00.pdf.
- US EPA. 2003c. "EPA Environmental Technology Verification Home" http://www.epa.gov/etv/.
- US EPA. Undated c. Compendium of Environmental Testing Laboratories. http://www.epa.gov/compendium
- US National Library of Medicine. 2001. Toxicology Tutor I - Basic Principles. May 14. http://www.sis.nlm.nih.gov/ToxTutor/Tox1/a12.htm
- WaterISAC, which contains information on contaminants including various contaminant fact sheets as well as the United Kingdom Water Industry Research (UKWIR) database: www.waterisac.org.
- WHO's "Public health response to biological and chemical weapons" www.who.int/csr/delibepidemics/biochemguide/en/index.html.
- WHO. 2001. "Health Aspects of Biological and Chemical Weapons" http://www.who.int/emc/pdfs/BIOWEAPONS_FULL_TEXT2.pdf

6.3 Threat Management Matrices

This section presents a "contamination threat management matrix" for each of the threat warnings described in Section 2.2. Each matrix is a tabular summary that lists the following at the 'possible,' 'credible,' and 'confirmatory' stages of the threat evaluation:

- Information considered during the threat evaluation.
- Factors considered during the threat evaluation.
- Potential response actions.

6.3.1 Security Breach

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Location of security breach. • Time of security breach. • Information from alarms. • Observations when security breach was discovered. • Additional details from the threat warning.	• Results of site characterization at location of security breach. • Previous security incidents. • Real time water quality data from the location of security breach. • Input from local law enforcement.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Was there an opportunity for contamination? • Has normal operational activity been ruled out? • Have other "harmless" causes been ruled out?	• Do site characterization results reveal signs of contamination? • Is this security breach similar to previous security incidents? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement agencies.	• Drinking water primacy agency. • State/local public health agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area. • Initiate site characterization. • Estimate spread of suspected contaminant. • Consult external information sources.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Security breaches may be the most common type of threat warning encountered by a utility since they may result from trespassing, vandalism, theft, or failure to re-secure facilities following legitimate activities. The purpose of the threat evaluation under this scenario is to distinguish between these more frequent, yet relatively harmless security breaches, and those few that might be considered 'credible' contamination threats.

At the 'possible' stage of the threat evaluation, information about the security breach will be available. Specifically, the location of the security breach will be known, which will likely be established as the initial investigation site. Other information may be available from alarms

(including surveillance footage), which may help to establish the time of the security breach. The evaluation at this stage should consider whether or not there was an opportunity for contamination at the site of the security breach. Furthermore, "normal" activity should be considered and investigated at this stage as a potential cause of the security breach (e.g., was a utility crew recently at the site and potentially forgot to re-secure the area?). Potential response actions to a 'possible' threat may include isolating areas of the system that could be affected, initiating site characterization activities to collect more information in support of the threat evaluation, and initiating the process to estimate the spread of the suspect water through the system.

Information that may be available at the 'credible' stage includes the results of site characterization, an assessment of previous security incidents, real-time water quality data in the area of the security breach, and an assessment of the threat by law enforcement. The evaluation at this stage will consider whether or not signs of contamination were discovered during site characterization, including unusual results from field testing or unusual observations during the site investigation. Consideration should also be given to whether or not the new information available at this stage corroborates the information about the threat. If the threat is determined to be 'credible,' response actions may include measures to limit or prevent exposure of the public to the suspect water, such as public notification. Actions taken to continue the investigation at this point may include analysis of samples collected from the site, continued site characterization activities, and an analysis to estimate the spread of the contaminant.

The new information available at the confirmatory stage may include the results from laboratory analysis, including QA/QC data to support the interpretation of the results. If a specific contaminant is identified, then additional information about that contaminant can be used to further evaluate the nature of the threat as well as implications to public health. The findings of continued site characterization activities may also help to confirm the incident. The basis for confirming a contamination incident can be analytical results that identify a specific contaminant or other definitive evidence that a contaminant is present in the water. If a contaminant has been identified, consideration should be given to the health effects associated with exposure to that contaminant. It may be necessary to revise the sampling and analysis plans if a contaminant was not positively identified through laboratory analysis but the threat is still deemed 'credible.' Response actions potentially initiated once a contamination incident has been confirmed include characterization of the contaminated area, revision to public health protection measures, provision of alternate water supplies, and planning for remediation and recovery activities.

6.3.2 Witness Account

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Location of the suspicious activity. • Witness account of the suspicious activity. • Additional details from the threat warning.	• Additional information from the witness. • Results of site characterization at location of suspicious activity. • Previous security incidents. • Real time water quality data from the location of suspicious activity. • Input from local law enforcement.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Was there an opportunity for contamination? • Is the witness reliable? • Has normal operational activity been ruled out? • Have other "harmless" causes been ruled out?	• Do site characterization results reveal signs of contamination? • Is the suspicious activity similar to previous security incidents? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement.	• Drinking water primacy agency. • State/local public health agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area. • Initiate site characterization. • Estimate spread of suspected contaminant. • Consult external information sources. • Interview witness for additional information.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

From the perspective of the threat management process, a threat triggered by a witness account is similar to one triggered by a security breach. One of the few significant differences is the use of information collected directly from the witness throughout the evaluation, particularly during the 'possible' and 'credible' stages of the threat evaluation. The reliability of the witness must be considered when making these determinations, and additional evidence collected during the investigation should be evaluated to determine whether or not it corroborates the witness account.

6.3.3 Direct Notification by Perpetrator

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Transcript of phone (or written) threat. • The who, what, where, when, and why of the threat. • Additional details from the threat warning. • Vulnerability assessment.	• Law enforcement assessment. • Primacy agency assessment. • Previous threats at this utility or other utilities. • Results of site characterization at selected investigation sites. • Real time water quality data. • Reports from ISAC, EPA, etc.	• FBI assessment. • Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Is the threat feasible? • Has the water already been contaminated? • Is the location known or suspected? • Is the identity of the perpetrator known or suspected? • Have there been personnel problems at the utility?	• Do site characterization results reveal signs of contamination? • Does other information (e.g., water quality) corroborate threat? • Does law enforcement consider this a credible threat? • Does the primacy agency consider this a credible threat?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility. • Local law enforcement. • Drinking water primacy agency.	• FBI. • State/local public health agency. • EPA Criminal Investigation Division.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Isolate affected area if identified in the threat. • Identify sites and initiate site characterization. • Consult external information sources. • Gather information from law enforcement assessment.	• Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites. • Estimate spread of suspected contaminant.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Threats to contaminate the water made via direct notification by a perpetrator need to be taken seriously. However, the majority of such direct threats are hoaxes that may be intended to cause panic or disruption, gain attention, or fulfill a personal vendetta. Thus, the focus of the threat evaluation for this type of threat warning is to identify any credible threats amongst the larger number of hoax notifications. In any case, direct threats against the water supply should be reported to local law enforcement.

A key source of information that may support the threat evaluation under this scenario is provided directly by the perpetrator making the threat. In the case of a phone threat, it is important to collect information about the threat from the caller to support the threat evaluation. Similarly, a written notification should be carefully reviewed for details about the threat. Additional information collected throughout the investigation should be evaluated against the details of the threat notification, and it corroborates the details of the notification, then the threat is more likely to be deemed 'credible.'

One of the potential challenges in managing a threat triggered by direct notification from a perpetrator is identification of an investigation site that will be the focus of site characterization activities. Unless a location is named in the threat, it will be necessary to use other information, such as that derived from vulnerability assessments or unusual water quality data/consumer complaints, to identify investigation sites.

6.3.4 Unusual Water Quality or Consumer Complaints

Unusual Water Quality

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Unusual water quality data. • Baseline water quality data. • Real time water quality data. • Operational information corresponding to the time of the unusual water quality.	• Results of site characterization at selected investigation sites. • Previous threat warnings triggered by water quality. • Contaminant information. • Reports of consumer complaints.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.
Evaluation	• Is the unusual water quality significantly different from an established baseline? • Could operational changes be the cause? • Could changes in source water quality be the cause? • Are there similar results at other monitoring locations?	• Do site characterization results reveal signs of contamination? • Is this unusual data substantial different from other water quality episodes? • Is the unusual data indicative of a specific contaminant? • Are the unusual water quality clustered in a specific area? • Are there any unusual consumer complaints in the area?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility.	• Drinking water primacy agency. • State/local public health agency. • Local law enforcement. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Identify sites and initiate site characterization. • Begin analysis of available water quality data. • Investigate unusual consumer complaints. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Consumer Complaint

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Compilation of consumer complaints, including geographic distribution. • Recent water quality data that may be associated with complaints. • Operational information corresponding to the time of the unusual complaints.	• Results of site characterization at selected investigation sites. • Summary of historic consumer complaints. • Results of consumer interviews. • Contaminant information.	• Results of sample analysis. • Contaminant information. • Results of site characterization at other investigation sites. • Input from primacy agency and public health agency.

Evaluation	• Are the complaints unusual? • Could operational changes be the cause? • Could changes in source water quality be the cause? • Are the complaints clustered in a specific area? • Are complaints from habitual complainers?	• Do site characterization results reveal signs of contamination? • Are other consumers in the area experiencing similar water quality? • Are the unusual complaints significantly different from typical complaints? • Are the complaints indicative of a specific contaminant? • Is there anything unusual about the water quality in the area?	• Were unusual contaminants detected during analysis? Do they pose a risk to the public? • Do site characterization results reveal signs of contamination? • Is contamination indicated by a "preponderance of evidence?"
Notifications	• Notifications within utility.	• Drinking water primacy agency. • State/local public health agency. • Local law enforcement agency. • FBI.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Identify sites and initiate site characterization. • Begin analysis of available water quality data. • Interview consumers in area with high numbers of complaints. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Analyze samples. • Perform site characterization at additional investigation sites.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

A threat warning arising from unusual water quality data is **significantly different** from the other threat warnings previously discussed and thus should be handled differently during the threat evaluation. In determining whether or not the threat is 'possible,' it is necessary to evaluate the anomalous data relative to an established baseline. Furthermore, it is important to consider operational conditions, or potential impacts from changing source water quality or distribution system blending as possible explanations for the unusual water quality or complaint. If the unusual water quality data is determined to be significantly different from the baseline, and cannot be explained by other factors, then t contamination may be considered a possibility.

Presumably, the unusual water quality data will be associated with a particular location in the system, which will help in the identification of investigation sites that will be the focus of site characterization activities. At this stage, it is important to verify the anomalous water quality data through additional testing using independent equipment. For example, if an incident was triggered by a rapid decrease in the free chlorine residual, as detected by online electrochemical monitors, additional testing could be performed with colormetric field kits to confirm the results. Additional rapid field testing might also help to determine the bounds of the affected area. Furthermore, specific information about particular contaminants should be considered at the 'credible' stage as it might be used to identify potential contaminants that would impact the water quality parameter with anomalous readings. For example, contaminants with acidic functional groups might result in reduced pH.

6.3.5 Notification by Public Health

	THREAT EVALUATION STAGE		
	Possible	**Credible**	**Confirmatory**
Information	• Details of notification from public health sector. • Symptoms of disease and causative agent, if known. • Contaminant information.	• Geographic distribution of disease or death. • Recent water quality and operational data. • Reports of consumer complaints. • Contaminant information.	• Results of site characterization at selected investigation sites. • Results of sample analysis. • Contaminant information. • FBI assessment.
Evaluation	• Why is water under investigation as a possible source? • Are the reported symptoms consistent with exposure to the contaminant via water? • If causative agent is known, is it stable in water?	• Is the geographic pattern of exposure consistent with exposure to contaminated water? • Is there a recent occurrence of unusual water quality data or consumer complaints? • Does additional information about the potential contaminant indicate water as a potential source?	• Has the public health agency concluded that water is the cause of the disease or deaths? • Did sample analysis detect the causative agent? • Was another contaminant detected during sample analysis that could be the cause of the disease or deaths?
Notifications	• Notifications within utility. • State/local public health agency. • Drinking water primacy agency.	• FBI. • Local and State law enforcement agencies.	• Emergency response agencies. • National Response Center. • Other state and federal assistance providers.
Response	• Consult with public health agency and primacy agency. • Consult external information sources.	• Estimate affected area and isolate if possible. • Implement appropriate public health protection measures. • Plan for alternate water supply. • Identify sites and initiate site characterization. • Analyze samples.	• Characterize affected area. • Revise public health protection measures as necessary. • Provide alternate water supply. • Plan remediation activities.

Notification from public health officials regarding a potential water contamination incident is unique in that individuals have been exposed to a harmful substance resulting in illness, disease or death in the population. The threat evaluation in this case may be part of a larger epidemiological investigation to determine the cause of disease. It is critical that the utility work with the appropriate public health officials from the outset, since these officials will likely have information critical for the evaluation. For example, they may know or suspect the causative agent based on clinical information. This knowledge, in conjunction with information about the properties of the contaminant, may indicate whether or not contaminated water is even a possibility. For example, if the causative agent is known to immediately break down into harmless byproducts upon exposure to water, then the possibility of contaminated water might be dismissed.

If water is considered a possible carrier for the contaminant, then further investigation should be conducted to determine if water is the most likely carrier of the contaminant (i.e., analogous to the 'credible' stage of the threat evaluation). Information that may help to make this determination will include additional findings from the larger epidemiological investigation, geographic distribution of exposure, recent water quality and operational data, and reports of

consumer complaints. If this additional information indicates that water contamination is likely, response actions would likely include public notification and sampling for the contaminant. The sampling plan developed at this point may start with information about the geographic distribution of exposure; however, consideration must be given to the latency period of the disease, which could be from minutes to weeks, as well as the travel time within the system. The objectives of sampling and analysis at this point would include: 1) confirming the presence of the contaminant in the water; 2) determining if the contaminant is still present; and 3) determining the area affected. If water contamination is confirmed, and the contaminant is still present in the system, it will be necessary to begin planning for remediation and recovery efforts. If the contaminant is not found, extensive sampling would likely be necessary to demonstrate that the contaminant is indeed absent from the system.

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-04-001
www.epa.gov/safewater/security
August 2004

Office of Ground Water and Drinking Water
Water Security Division
EPA 817-D-04-001
www.epa.gov/safewater/security
August 2004

Printed on Recycled Paper