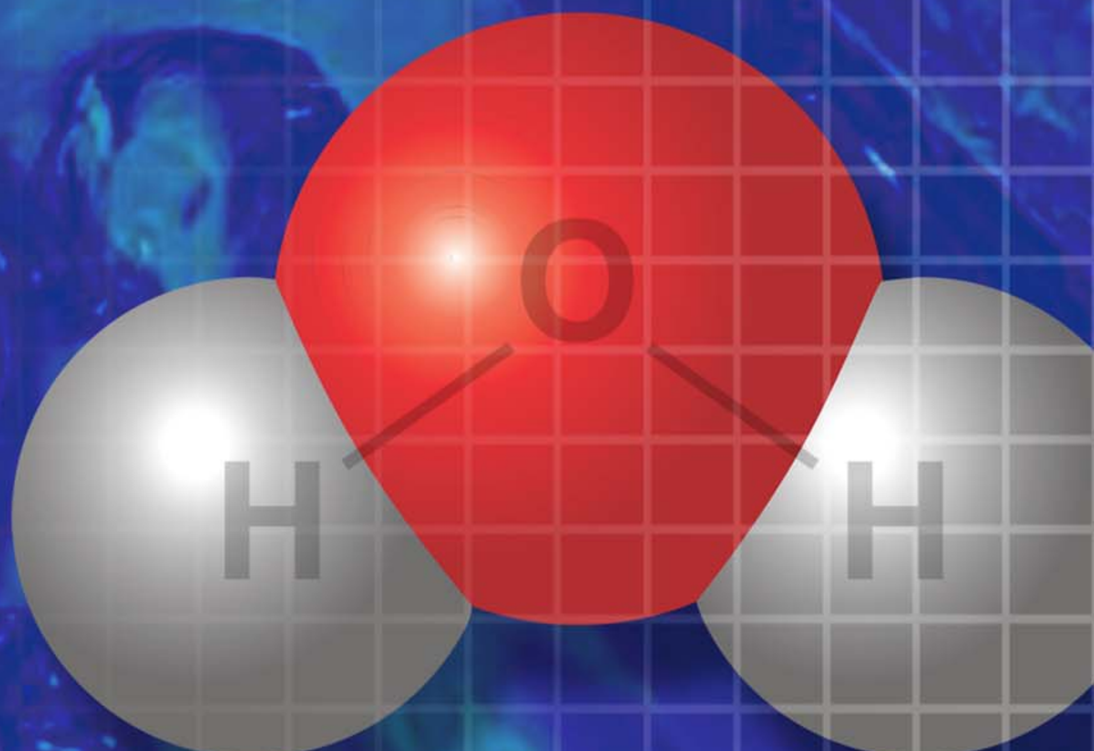
The Water Security Research and Technical Support Action Plan



"We're... taking significant steps to strengthen our homeland protections — securing cockpits, tightening our borders, stockpiling vaccines, increasing security at water treatment and nuclear power plants."

President George W. Bush
June 6, 2002

EPA/600/R-04/063
March 2004

WATER SECURITY RESEARCH AND TECHNICAL SUPPORT ACTION PLAN

Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

and

Office of Water
U. S. Environmental Protection Agency
Washington, DC 20460

Notice

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

Foreword

We are pleased to share with you the *Water Security Research and Technical Support Action Plan (Action Plan)*. The *Action Plan* presents the results of a collaborative effort between the U.S. Environmental Protection Agency (EPA), federal partners, the water industry, public health organizations, and the emergency response community to identify the most pressing needs related to drinking water and wastewater security. A draft of the *Action Plan* was peer-reviewed by the National Research Council's Panel on Water System Security Research, which was organized in response to a request by EPA. We thank the panel for their fast-track provision of valuable comments and recommendations.

The *Action Plan* identifies critical research and technical support projects in the areas of physical and cyber infrastructure protection; contaminant identification; monitoring and analysis; treatment, decontamination, and disposal; contingency planning; infrastructure interdependencies; and risk assessment and communication. The projects described in the *Action Plan* are intended to improve our understanding of the public health and environmental impacts of different kinds of attacks on water infrastructure. This knowledge, when applied and integrated into practices of the water security sector, will lead to improved awareness, preparedness, prevention, response, and recovery from intentional acts against water systems.

The very nature of protecting the nation's water infrastructure is a dynamic and evolving process that requires flexibility. The *Action Plan* will, therefore, be periodically updated to reflect new or additional information on possible threats to water infrastructure and executive or legislative mandates and directives on homeland security.

The water sector will benefit from the new knowledge, methodologies, tools and other products generated as we implement this *Action Plan*.

E. Timothy Oppelt, Director
National Homeland Security Research Center

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

Peer Review

Peer review is an important component of the *Water Security Research and Technical Support Action Plan.* The peer review history for this document is as follows:

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Initial Internal Agency Review:	January 18-21, 2003
Stakeholders Meeting:	February 5-7, 2003
Second Internal Agency Review:	April 1-4, 2003
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Reviewers:

Garret P. Westerhoff, *Chair*, Malcolm Pirnie, Inc., White Plains, NY
Gregory B. Baecher, University of Maryland, College Park
Joseph A. Cotruvo, Joseph Cotruvo and Associates, Washington, DC
Gunther F. Craun, Gunther F. Craun and Associates, Staunton, VA
Charles N. Haas, Drexel University, Philadelphia, PA
James B. McDaniel, Los Angeles Department of Water and Power, Los Angeles, CA
Charles R. O'Melia, Johns Hopkins University, Baltimore, MD
David M. Ozonoff, Boston University School of Public Health, Boston, MA
Kerry Kirk Pflugh, New Jersey Department of Environmental Protection, Trenton, NJ
David A. Reckhow, University of Massachusetts, Amherst, MA
David P. Spath, California Department of Health Services, Sacramento, CA
Marylynn V. Yates, University of California, Riverside, CA

Consultant to the Panel:

David R. Siburg, Kitsap Public Utility District, Poulsbo, WA

National Research Council Staff:

Stephanie E. Johnson, Study Director
Laura J. Ehlers, Senior Staff Officer
Dorothy K. Weir, Project Assistant

Coordinated by:

Stephanie Johnson
Water Technology Science Board
National Research Council
500 Fifth Street, NW
Washington, DC 20001

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Acknowledgments

The *Water Security Research and Technical Support Action Plan* was prepared by Office of Water (OW) and Office of Research and Development (ORD) scientists and engineers. Co-leaders were Jonathan Herrmann of ORD and Hiba Shukairy of OW (September 2002 through May 2003). Grace Robiou led the OW contributions beginning in June 2003.

Major contributors included: Steve Allgeier (OW), Curt Baranowski (OW), Eletha Brady-Roberts (ORD), Kim Fox (ORD), Alan Hais (ORD), Jonathan Herrmann (ORD), Richard Hertzberg (ORD), Eric Koglin (ORD), Alan Lindquist (ORD), Matthew Magnuson (ORD), Scott Minamyer (ORD), Dan Murray (ORD), Regan Murray (ORD), Grace Robiou (OW), Hiba Shukairy (OW), and Kenneth Stone (ORD).

Numerous helpful comments were provided during several reviews by Janet Pawlukiewicz (OW), Tim Oppelt (ORD), and Cayce Parrish (formerly OW, now EPA's Office of Homeland Security). Virginia Hodge (SAIC) was most supportive in preparing the peer review draft and draft final versions of the *Water Security Research and Technical Support Action Plan*.

Acronyms and Abbreviations

CDC	Centers for Disease Control and Prevention
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DSRC	Distribution System Research Consortium
EPA	Environmental Protection Agency
ETV	Environmental Technology Verification
EWS	early warning system
FDA	Food and Drug Administration
GIS	geographic information system
HSPD	Homeland Security Presidential Directive
IAG	Interagency Agreement
ISAC	Information Sharing and Analysis Center
LD_{50}	lethal dose 50 (dose causing death in 50% of the exposed animals)
MOU	Memorandum of Understanding
NBC	nuclear, biological, or chemical
NEMI	National Environmental Methods Index
NHSRC	National Homeland Security Research Center
NOAEL	no-observed-adverse-effect-level
NRC	National Research Council
PDD	Presidential Decision Directive
PL	Public Law
POU/POE	point-of-use/point-of-entry
QSAR	Quantitative Structure Activity Relationship
SCADA	supervisory control and data acquisition
TSWG	Technology Support Working Group
WERF	Water Environment Research Foundation
WPTF	Water Protection Task Force
WSD	Water Security Division

Executive Summary

Introduction

Water — every drop of it — is a precious natural resource that Americans once enjoyed with little thought to potential tampering by terrorists or others. Today, however, U. S. citizens are increasingly aware of threats of harm to our homeland. The terrorist attacks of September 11, 2001, and the delivery of anthrax-contaminated letters later that year have taught all of us to anticipate that threats to water are possible.

Terrorist threats are targeted not just at individuals, but also at the country's vital institutions and infrastructure, including the nation's drinking water and wastewater systems. Government, water utilities, state and local water agencies, public health organizations, emergency and follow-up responders, and academia, as well as the private sector from across the country must be ready to protect water infrastructure. These organizations are working together to reduce vulnerabilities to terrorism, prevent and prepare for terrorist attacks, minimize public health impacts and infrastructure damage, and enhance recovery from any attacks that may occur.

EPA's Water Security Role

The *Public Health Security and Bioterrorism Preparedness and Response Act* (Bioterrorism Act) of 2002 is the legislative mandate for the U.S. Environmental Protection Agency's (EPA) work in water security. This law, coupled with executive directives and the Agency's own strategic plan for homeland security, guide the Agency's research and technical support activities to protect the water infrastructure. The Homeland Security Presidential Directive (HSPD) 7, *Critical Infrastructure Identification, Prioritization, and Protection,* reinforces EPA's role as the sector-specific lead for water infrastructure. It also assigns the responsibility of coordinating the overall national effort to protect critical infrastructure and key resources of the United States to the Department of Homeland Security.

As the sector-specific federal lead for protecting the nation's drinking water and wastewater infrastructures, EPA plays a critical role in the homeland security arena. To meet these responsibilities, the Agency's Office of Water established the Water Protection Task Force. The Task Force was formally organized as the Water Security Division (WSD) in August 2003. Additionally, the Agency's Office of Research and Development (ORD) officially established the National Homeland Security Research Center (NHSRC) in February 2003. These organizations work together in providing research and technical support to the drinking water and wastewater sectors.

NHSRC's Water Security Team contributes by conducting applied research and then reporting on ways to better secure the nation's water systems from threats and attacks. The Team is producing analytical tools and procedures, technology evaluations, models and methodologies, decontamination techniques, technical resource guides and protocols, and risk assessment methods. All of these products are for use by EPA's key water infrastructure customers — water utility operators, public health officials, and emergency and follow-up responders. Other research programs in NHSRC deal with the protection of buildings and rapid risk assessment.

WSD provides support to drinking water and wastewater systems by preparing vulnerability assessment and emergency response systems and tools, providing technical and financial assistance, and developing information exchange mechanisms. WSD is also charged with supporting best security practices, providing security enhancement guidance, and incorporating security into the day-to-day operations of the drinking water and wastewater industries. In addition, WSD works closely with NHSRC in delivering research results in a timely and appropriate fashion.

Along with providing research and technical support, both NHSRC and WSD encourage information sharing and risk communication strategies among key water infrastructure customers. This includes making use of the Water Information Sharing and Analysis Center (WaterISAC).

Water Security Research and Technical Support Action Plan

To better understand the security problems of the water industry in the United States, EPA has engaged with numerous water experts and stakeholders from government, industry, and academia. Other key participants are representatives from public health organizations, emergency responders and follow-up responders, law enforcement officials, environmental groups, and related professional associations.

As a result of these meetings, EPA has gained valuable insights on the vulnerabilities and technical challenges facing the water industry for which research and technical support are crucial. With assistance from other federal agencies and contractors, both WSD and NHSRC are addressing these challenges. Issues, needs, and projects are summarized in this comprehensive *Water Security Research and Technical Support Action Plan*, hereafter referred to as the Action Plan.

Much of the work described in the Action Plan has begun, and what is not underway will start over the next few months. The Action Plan must be recognized as a snapshot in time. As new information is developed on threats, contaminants, and threat situations, adjustments will most certainly be necessary. Revisions to the Action Plan will be made periodically based on input from others dealing with drinking water and wastewater security. The Action Plan will also evolve based on the changing needs in the homeland security arena.

The Action Plan addresses drinking water supply, water treatment, finished water storage, and drinking water distribution system infrastructure. It also addresses wastewater treatment and collection infrastructure, which includes sanitary and storm sewers or combined sanitary-storm sewer systems, wastewater treatment, and treated wastewater discharges.

Research and Technical Support Questions

In various meetings with EPA, federal partners and water stakeholders discussed issues, needs, and projects to secure water infrastructure and safeguard water quality. The Action Plan developed as a result of these meetings describes research and technical support that addresses many questions focused on protecting water infrastructure. Some of the questions are as follows:

Drinking Water Questions

- What are the most plausible threats, contaminants, and threat scenarios facing the drinking water industry? How does this information compare with intelligence information on possible threats?
- What types of biological and chemical contaminants could be introduced into water systems and what are their physical, chemical, and biological properties? What are the potential health impacts of these contaminants?
- What are the most effective means to detect contaminants in water? How can this information be combined with reporting, analysis, and decision making to arrive at a reliable and cost-effective early warning system?
- Can effective methods be developed to ensure that a sufficient number of qualified laboratories exist to perform rapid analysis of water contaminants in the event of an attack?
- If contaminants were introduced into a water system, where will they travel? How quickly will they travel? What will be their concentration at various points along their path? Can human exposures and the health impacts of these contaminants be effectively minimized?
- How can water that has been contaminated be effectively treated so that it can be released to wastewater systems or otherwise disposed of?
- Are alternative water supplies available in the event of an attack? How would water utilities or governments most effectively supply clean water to affected communities and businesses in both the short and long term?

- What are the routes of human exposure to contaminants if a water system were attacked? What are the acute and chronic impacts from these exposures and can they be adequately represented based on existing risk information?

- Can a health surveillance network be established to rapidly identify disease outbreaks associated with contaminated water? Are there other means of providing early warnings or alerts from water contamination using surrogate health data?

Wastewater Questions

- What are the risks of hazardous substances that may be introduced into wastewater treatment systems?

- Can intrusion and surveillance monitoring technologies be improved to rapidly detect water contamination and alert authorities should a wastewater facility be compromised?

- Are alternative wastewater treatments and discharge locations available in the event of an attack?

- What are the most plausible threats, contaminants, and threat scenarios facing the wastewater industry? How does this information compare with intelligence information on possible threats?

Information Questions

- How best can emergency responders, public health officials, health care providers, and the public be effectively and efficiently informed in the event of an attack?

- What are some risk communication principles that drinking water and wastewater systems could employ to better respond to crisis situations?

Action Plan Issues and Needs

Results from federal partner and water stakeholder meetings are organized in the Action Plan under the seven issues listed below. Each issue describes significant research needs and lists specific projects for each need. Although the Action Plan focuses primarily on biological, chemical, and radiological contaminants in drinking water systems, it also addresses physical and cyber threats, contingency planning, risk assessment, risk communication, and infrastructure interdependencies:

- Protecting drinking water systems from physical and cyber threats

- Identifying drinking water threats, contaminants, and threat scenarios

- Improving analytical methodologies and monitoring systems for drinking water

- Containing, treating, decontaminating, and disposing of contaminated water and materials

- Planning for contingencies and addressing infrastructure interdependencies

- Targeting impacts on human health and informing the public about risks

- Protecting wastewater treatment and collection systems.

How these issues are being addressed and the resulting products delivered are described in the Chapter 5 of the Action Plan. The following approach is being used:

- Enhancing collaborative research and technical support

- Providing for technology advancement through testing, evaluation, and verification

- Sharing information in both secure and open fashions.

Some of the research and technical support needs are identified below:

- Ensure the protection of existing water infrastructure

- Enhance cyber security and other external means of disrupting water systems

- Identify and characterize threats that could be used to disrupt water systems

- Develop methods for detecting and monitoring contaminants in water

- Create rapid screening technologies for the identification of unknown contaminants

- Test and evaluate the performance of sensors and biomonitors
- Improve detectors and early warning systems for water distribution and collection systems
- Enhance models for contaminant transport in pipes and distribution systems
- Refine fate and transport information for contaminants in water
- Develop treatment or inactivation techniques for water contaminants
- Evaluate and improve decontamination and disposal techniques for contaminated materials and equipment
- Establish contingency planning and infrastructure backup procedures
- Improve methods for assessing risks to the public from water contamination
- Enhance risk communication and information sharing among individuals and organizations dealing with a threat or attack
- Provide training and exercises that enhance preparedness, response, and mitigation to water system threats or attacks.

The challenges facing EPA in securing water infrastructure are interdependent and complex. The goal of the Action Plan is to provide useful and timely products to key water infrastructure customers that help protect drinking water and wastewater systems.

Action Plan Products

EPA's research and technical support activities will result in various types of products, tools, and technologies. There are a variety of groups that will use the information developed under the Action Plan:

- Water industry representatives
- State, regional, and local response organizations
- Public health officials and organizations
- Federal agencies and departments
- Laboratories with water sample testing capabilities
- Academia and consulting firms
- Elected officials and the public.

Because of the diverse nature of the above information users, the products must be tailored to a variety of audiences. Publicly available interim research products will be placed on NHSRC's Web site at: http://www.epa.gov/ordnhsrc. An Internet-based catalog with publicly available products from both WSD and NHSRC will be located on the WSD Web site at: http://www.epa.gov/safewater/security. Some examples of products include, but are not limited to:

- Computerized data compendiums
- Response guides and protocols
- Technical resource documents, case studies, and model procedures
- Laboratory methods and protocols
- Communication tools and frameworks
- Technology screening, evaluation, and verification
- Workshops and training
- Computerized tools and software systems
- Risk assessment methods and procedures
- Journal articles, fact sheets, and technical bulletins.

Work in progress will be shared in open forums such as journals, Web sites, and meetings. If the information is sensitive, it will be provided using more limited venues such as the WaterISAC. EPA information clearinghouses, booths at conferences and workshops, and announcements and press releases will be used to deliver Action Plan results as well.

Future Actions

With a long history in environmental protection, and assessing and managing risks, EPA is well-positioned to develop the tools and technologies that address threats to and attacks on drinking water and wastewater systems. As the lead for the research under this Action Plan, NHSRC is providing information that can be quickly used by those with a stake in securing the water system infrastructure. As the lead for technical support to key customers in the water arena, WSD is charged with a much broader responsibility that is informed by NHSRC's research.

The Action Plan is a collaborative undertaking that involves EPA and many others. Both NHSRC and WSD will continue to foster this kind of an approach by routinely engaging individuals and organizations with a vital interest in water security. This allows for quick adaptation of the Action Plan to meet the most pressing needs in protecting water infrastructure from terrorist threats and attacks.

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Chapter 1
Introduction

The citizens of the United States face increased threats of harm since the terrorist attacks of September 11, 2001, and the delivery of anthrax-contaminated letters later that year. These threats relate not just to individuals, but also to the country's vital institutions, systems, and infrastructure. The U.S. Environmental Protection Agency (EPA) provided its detailed response to water-related threats in the *Strategic Plan for Homeland Security* (hereafter called the EPA Strategic Plan) [Ref. 1]. The EPA Strategic Plan defines the Agency's responsibility to protect the nation's water and wastewater systems, and is described in greater detail in Chapter 2 of this document.

As the lead federal agency protecting water systems from terrorist attacks, EPA efforts focus on physical security, cyber security, and the risk associated with delivery of chemical, biological, and radiological contaminants into water systems. This approach fits well within the Agency's mission of protecting public health and safeguarding the natural environment upon which life depends.

As illustrated in Figure 1.1, EPA is working to improve the security of drinking water and wastewater systems by focusing on financial assistance, the development of tools and training, emergency response, incorporation of security into the water business, information sharing, and

Figure 1.1. The Context of Research and Technical Support Relative to the EPA's Water Security Program

research and technical support. The Water Security Division (WSD) has developed numerous projects to satisfy the needs of the water industry in these areas. Research and technical support is only one component of the EPA's water security program.

The National Homeland Security Research Center (NHSRC) is collaborating with the WSD to identify and address research and technical support needs. The WSD and NHSRC have worked with federal partners and stakeholders to develop and implement this comprehensive *Water Security Research and Technical Support Action Plan* (hereafter referred to as the Action Plan), which will undergo periodic updating as issues evolve and additional needs are recognized.

The products that result from this Action Plan will be contained in a comprehensive and integrated catalogue. Types of products may include Web sites, response guides, reports, compendiums, handbooks, technical resources, workshops, seminars, training, exercises, information systems, newsletters, model protocols, journal articles, and risk communication strategies. This continually updated catalogue of available products, as well as many of the products themselves, will be available through EPA Web sites. EPA also envisions that hard copies of the catalogue and products will be available through EPA information clearinghouses. The actual structure of the catalogue is still undergoing development and will evolve as products are produced and venues for sharing information become more refined.

1.1 Purpose of the Action Plan

The purpose of the Action Plan is to: (1) identify important water security issues for drinking water and wastewater, (2) describe research and technical support needs that address these issues, and (3) present a list of projects that are responsive to the identified needs. To accurately represent the needs of the water sector, representatives of the water industry and other stakeholders, in collaboration with EPA and its federal partners, proposed and refined the issues and needs presented in the Action Plan throughout 2003.

Figure 1.2 aids the reader in navigating the chapters of the Action Plan. Each section of Chapters 3 and 4 begins with the key research and technical support questions to be addressed. From these questions, needs were developed and projects defined to meet those needs.

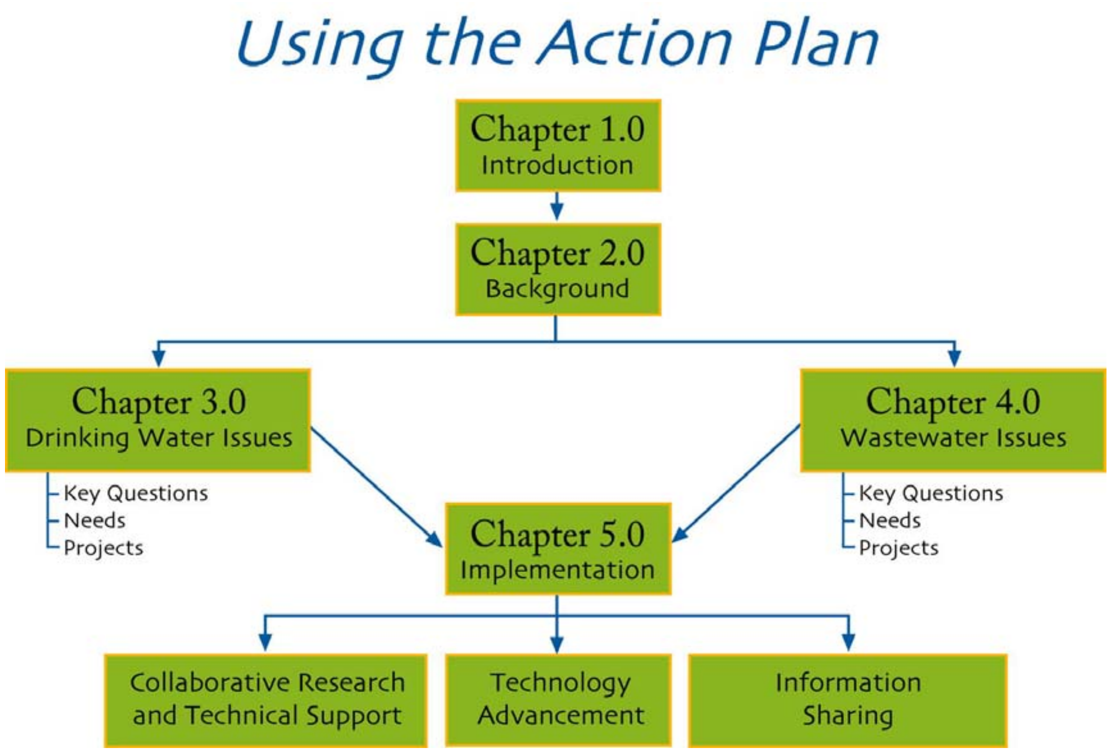


Figure 1.2. Flow Chart for Navigating the *Water Security Research and Technical Support Action Plan*

The Action Plan focuses on both drinking water (Chapter 3) and wastewater (Chapter 4), and addresses needs and projects in the following areas:

- Physical protection of the water infrastructure, including cyber security
- Identification and characterization of contaminants
- Monitoring and detection of contaminants
- Containment, treatment, decontamination, and disposal of contaminated materials
- Contingency planning and infrastructure interdependencies
- Risk assessment and risk communication.

Chapter 5 describes Action Plan implementation, and includes discussions on research collaboration, technology advancement, and information sharing activities.

1.2 Laws and Documents Driving the Action Plan

Research and technical support for water security must be responsive to and, more importantly, forward thinking in ensuring that water supplies and systems remain safe and secure. Three principal drivers led to the development of this Action Plan, and were critical in framing the research and technical support needs in Chapters 3 and 4. These drivers were:

- The EPA *Strategic Plan for Homeland Security* (September 2002) [Ref.1]
- The *Public Health Security and Bioterrorism Preparedness and Response Act* (June 2002) [Ref. 2]
- A set of research and technical support needs prepared by the EPA's Water Protection Task Force (WPTF), now WSD (February 2002).

These are described in more detail in Chapter 2, and will enable EPA to measure its progress as this Action Plan is implemented in the coming years. EPA will continue to identify and respond quickly to additional water security needs throughout the implementation of this Action Plan. The threats to water infrastructure are dynamic and change based on information gathered by the intelligence community and from other sources.

1.3 Process for Development of the Action Plan

Using the drivers presented above and the additional guiding documents discussed in Chapter 2, EPA convened a meeting of federal partners (Water Security Research Partners Meeting, Cincinnati, Ohio) in November 2002, to discuss and refine water security issues and needs. The Cincinnati meeting also included a number of water utility representatives. Based on the invaluable input from meeting participants, the Action Plan was prepared and presented at a meeting of stakeholders (Water Security Research Stakeholders Meeting, Washington, DC) in February 2003. The Action Plan was well received by the stakeholders, and additional needs and projects were proposed that were included in a Peer Review Draft of the Action Plan. In developing and implementing this Action Plan, EPA has made it a point to engage:

- Drinking water and wastewater utilities, water organizations, and other water stakeholders
- Public health officials and organizations
- Emergency and remedial response organizations.

The next step in developing this Action Plan was to obtain peer review from a representative group of water experts. The purpose of the May 2003 and July 2003 meetings with the National Research Council (NRC) of the National Academies was for EPA to consult with an independent peer review panel and obtain their assessment of this Action Plan. Comments were received from the peer review panel on July 28, 2003 and October 15, 2003. EPA reviewed these comments, and incorporated most of them into this Action Plan.

EPA also worked with the Water Environment Research Foundation (WERF) to more fully develop needs and projects related to improving wastewater security. EPA and WERF collaborated to conduct a stakeholder wastewater security symposium in Washington, DC in August 2003. The needs and projects for wastewater security identified at the WERF symposium are also reflected in this Action Plan.

Some projects described in this Action Plan are essential to EPA's homeland security efforts and have already started (in 2002 and 2003), while others are being initiated in fiscal year 2004. Some of the critical needs already being addressed relate to threat assessment; contaminant identification and methods development; technology testing, evaluation, and verification; and distribution system modeling.

The needs and associated projects identified in this Action Plan are another step in the direction of enhancing national water security. The Action Plan is designed to describe the universe of water security needs as best understood at the present time.

The projects presented in this Action Plan do not reflect resources or who will be addressing them; such decisions will be made as budgets are allocated. This likely will mean that important needs and projects will have to be addressed by others with a vested interest in protecting the nation's water systems. Such organizations include other federal agencies, the water industry and its research organizations, and to some degree the private sector.

1.4 Delivering Information

Information from Action Plan activities must be conveyed and communicated in a timely and useful fashion. This approach is confirmed by statements in the *National Strategy for Homeland Security* [Ref. 3], which describes a national vision of information sharing – a "system of systems" that "*provides the right information to the right people at all times.*" According to this vision, "*…information will be shared 'horizontally' across each level of government and 'vertically' among federal, state, and local governments, private industry, and citizens ... [so that] ... homeland security officials ... can have complete and common awareness of threats and vulnerabilities as well as knowledge of the personnel and resources available to help address those threats.*"

A variety of organizations and individuals will be involved along the continuum of preparing for, preventing, and responding to a threat to or attack on a water system. Examples include:

- Water industry representatives
- State, regional, and local response organizations
- Public health officials and organizations
- Federal agencies and departments
- Laboratories with water sample testing capabilities
- Academia and consulting firms
- Elected officials and the public.

As either NHSRC or the WSD produces new information under this Action Plan, all of the above users will be considered.

Chapter 2

Action Plan Background

In the President's *National Strategy for Homeland Security* [Ref. 3] published by the Office for Homeland Security in July 2002, EPA is designated as the lead federal agency for protecting the water sector, from source water through use, treatment, and discharge (see Figure 2.1). This designation is consistent with Presidential Decision Directive (PDD) 63 (see Table 2.1) [Ref. 4].

The *Public Health Security and Bioterrorism Preparedness and Response Act* [Ref. 2] signed by President Bush in June 2002 specifies several activities EPA must take to help community water systems improve security. Most recently, Homeland Security Presidential Directive (HSPD) 7, *Critical Infrastructure Identification, Prioritization, and Protection* [Ref. 5], directs the EPA to identify threats and take the lead role in protecting drinking water and wastewater treatment systems. These and other documents describe EPA's expanded role in countering terrorism, thereby ensuring that the nation's water systems are safe and secure.

The rest of this Chapter summarizes the key documents that support EPA's role in water security research and technical support. It provides the rationale and background information that was used to develop this Action Plan. These documents include Executive Orders, PDDs, internal EPA evaluations, the *Public Health Security and Bioterrorism Preparedness and Response Act* (Public Law [PL] 107-188 [hereafter referred to as the Bioterrorism Act]), the *National Strategy for Homeland Security* (hereafter referred to as the National Strategy), the EPA *Strategic Plan for Homeland Security* (hereafter referred to as the EPA Strategic Plan), and a report by the NRC entitled *Making Our Nation Safer: The Role of Science and Technology in Countering Terrorism*.

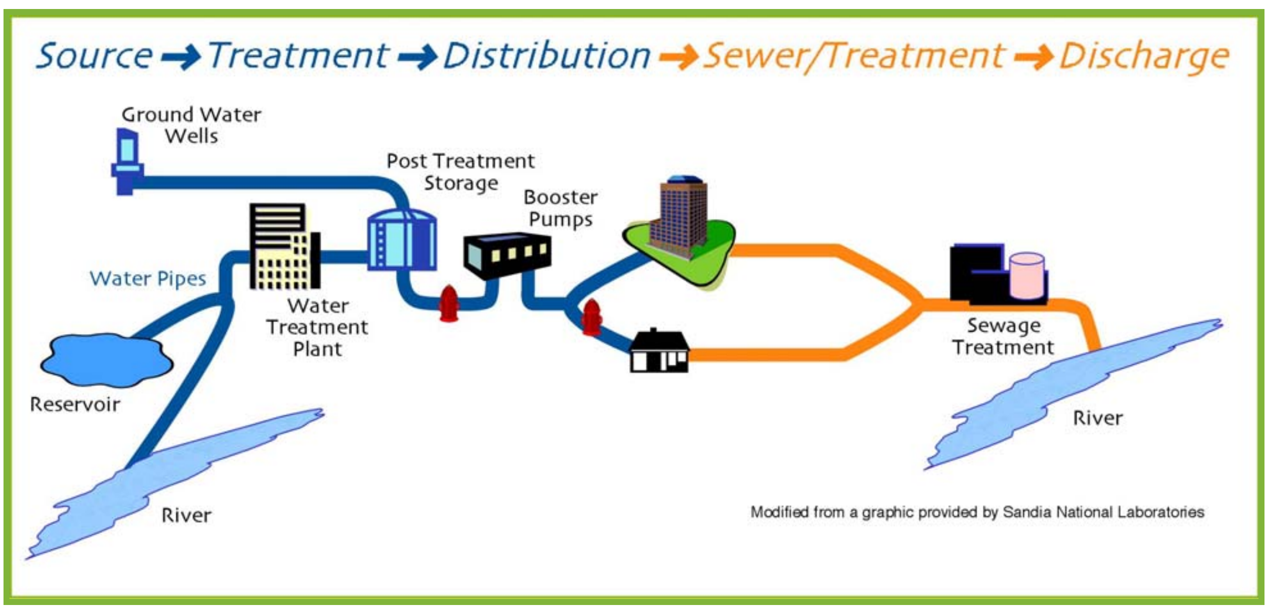


Figure 2.1. EPA Is the Designated Lead Federal Agency for Protecting the Water Sector, From Source Water Through Use, Treatment, and Discharge

2.1 EPA's Pre-September 11th National Security Role

EPA has long held responsibilities related to national security. Executive Order 12656, *Assignment of Emergency Preparedness Responsibilities*, directs the Agency to take on two responsibilities: (1) develop guidance on acceptable emergency levels of nuclear, biological, or chemical (NBC) materials, and (2) develop plans to ensure the availability of potable water after a national security incident [Ref. 6, Part 16]. Several legislative acts also shape EPA's role in responding to national security emergencies, including the Comprehensive Environmental Response, Compensation and Liability Act [Ref. 7], the Emergency Planning and Community Right-to-Know Act [Ref. 8], the Clean Water Act [Ref. 9], the Oil Pollution Act [Ref. 10], and the Clean Air Act [Ref. 11], among others.

PDD 39, *United States Policy on Counterterrorism*, signed by President Clinton in June 1995, requires all federal agencies to plan and prepare for terrorist attacks. In particular, PDD 39 requires EPA to provide environmental response support to the Federal Bureau of Investigation in the case of an NBC or any weapon of mass destruction event [Ref. 12]. Also, PDD 63, *Critical Infrastructure Protection*, signed in May 1998, introduces a public/private partnership to protect the nation's critical infrastructure and ensure the orderly functioning of the economy and critical services. The partnership is responsible for assessing the vulnerabilities of the water sector to cyber or physical attacks, recommending a plan to eliminate significant vulnerabilities, proposing a system for identifying and preventing major attacks, and developing a plan for reconstituting essential capabilities after an attack. PDD 63 lists water systems as part of the nation's critical infrastructure and designates EPA as the lead agency for protecting water systems from intentional attacks [Ref. 4]. PDD 63 also "…*strongly encourages the creation of a private sector information sharing and analysis center [ISAC] for critical infrastructures*." The Association of Metropolitan Water Agencies is the lead for the WaterISAC, which was launched in December 2002 [Ref. 13].

2.2 EPA's Evaluation of Past and Present Contamination Threat Information

In response to the events of September 11, 2001, EPA created the WPTF in the Agency's Office of Ground Water and Drinking Water. The WPTF, later formalized as the WSD, works with drinking water and wastewater systems personnel to enhance their security. One of the first efforts of the WSD was to evaluate past and present research related to the contamination of drinking water. EPA convened an interagency meeting to gather the latest information regarding contamination threats to water systems. This information generated a list of research needs, which is the baseline for this Action Plan.

Table 2.1. Federal Government Organization to Protect Critical Infrastructure and Key Assets

Sector	Lead Agency
Agriculture	Department of Agriculture
Food	*Meat and Poultry* – Department of Agriculture *Other Products* – Department of Health and Human Services
Water	Environmental Protection Agency
Public Health	Department of Health and Human Services
Emergency Services	Department of Homeland Security
Government	Department of Homeland Security and all other agencies
Defense	Department of Defense
Information and Telecommunications	Department of Homeland Security
Energy	Department of Energy
Transportation	Department of Homeland Security
Banking and Finance	Department of the Treasury
Chemical Industry	Department of Homeland Security*
Postal and Shipping	Department of Homeland Security
National Monuments and Icons	Department of the Interior

* Changed from the Environmental Protection Agency to the Department of Homeland Security by HSPD 7 [Ref. 5].

EPA developed guidance on threats facing water systems and made it available to community drinking water systems that serve populations greater than 3,300. Community drinking water systems of that size or larger are required by the Bioterrorism Act to complete vulnerability assessments. This guidance presents an overview of threats, methodologies, strategies, and responses for water utilities to consider when conducting these assessments. It describes which kinds of terrorist attacks or other intentional acts are likely to: (a) substantially disrupt the ability of a system to provide a safe and reliable supply of drinking water, or (b) otherwise present significant public health concerns.

2.3 Public Heath Security and Bioterrorism Preparedness and Response Act of 2002

President Bush signed PL 107-188, commonly referred to as the Bioterrorism Act, on June 12, 2002. This law authorizes funds for national, state, and local efforts to address bioterrorism and other public health emergencies; establishes controls for dangerous biological contaminants and toxins; authorizes funding for food and drug safety; and mandates protections for the drinking water industry, requiring that: (1) water systems serving more than 3,300 persons perform vulnerability assessments, and (2) EPA review methods to protect water systems.

Title IV of the Bioterrorism Act amends the Safe Drinking Water Act [Ref. 14] by adding the following sections:

- Section 1433 – *Terrorist and Other Intentional Acts* – requires community water systems to perform and submit to EPA vulnerability assessments and a certificate that they have completed the assessment. Also, these systems must develop or revise emergency response plans and submit a certification. It also requires the EPA to provide these systems with baseline threat information.

- Section 1434 – *Contaminant Prevention, Detection, and Response* – directs EPA to review methods to prevent, detect, and respond to the intentional contamination of water systems, including a review of equipment, early warning notification systems, awareness programs, distribution systems, treatment technologies, and biomedical research.

  Specifically, the Bioterrorism Act directs EPA to review each of the following:

  (1) Methods, means and equipment, including real time monitoring systems, designed to monitor and detect various levels of chemical, biological, and radiological contaminants or indicators of contaminants and reduce the likelihood that such contaminants can be successfully introduced into public water systems and source water intended to be used for drinking water.

  (2) Methods and means to provide sufficient notice to operators of public water systems, and individuals served by such systems, of the introduction of chemical, biological or radiological contaminants and the possible effect of such introduction on public health and the safety and supply of drinking water.

  (3) Methods and means for developing educational and awareness programs for community water systems.

  (4) Procedures and equipment necessary to prevent the flow of contaminated drinking water to individuals served by public water systems.

  (5) Methods, means, and equipment which could negate or mitigate deleterious effects on public health and the safety and supply caused by the introduction of contaminants into water intended to be used for drinking water, including an examination of the effectiveness of various drinking water technologies in removing, inactivating, or neutralizing biological, chemical, and radiological contaminants.

  (6) Biomedical research into the short-term and long-term impacts on public health of various chemical, biological, and radiological contaminants that may be introduced into water systems through terrorist or other intentional acts.

- Section 1435 – *Supply Disruption Prevention, Detection, and Response* – requires the review of methods by which the water system and all its parts could be intentionally disrupted or rendered ineffective or unsafe, including methods to interrupt the physical infrastructure, the computer infrastructure, and the treatment process. Specifically, the Bioterrorism Act directs EPA to review each of the following:

  (a)(1) Methods and means by which pipes and other constructed conveyances utilized in public water systems could be destroyed or otherwise prevented from providing adequate supplies of drinking water meeting applicable public health standards.

  (a)(2) Methods and means by which collection, pretreatment, treatment, storage and distribution facilities utilized or used in connection with public water systems and collection and pretreatment storage facilities used in connection with public

water systems could be destroyed or otherwise prevented from providing adequate supplies of drinking water meeting applicable public health standards.

(a)(3) Methods and means by which pipes, constructed conveyances, collection, pretreatment, treatment, storage and distribution systems that are utilized in connection with public water systems could be altered or affected so as to be subject to cross-contamination of drinking water supplies.

(a)(4) Methods and means by which pipes, constructed conveyances, collection, pretreatment, treatment, storage and distribution systems that are utilized in connection with public water systems could be reasonably protected from terrorist attacks or other acts intended to disrupt the supply or affect the safety of drinking water.

(a)(5) Methods and means by which information systems, including process controls and supervisory control and data acquisition and cyber systems at community water systems could be disrupted by terrorists or other groups.

(b) Methods and means by which alternative supplies of drinking water could be provided in the event of the destruction, impairment or contamination of public water systems.

The Bioterrorism Act also directs the EPA Administrator to:

(c)(1) Ensure that reviews carried out under this section reflect the needs of community water systems of various sizes and various geographic areas of the United States.

(c)(2) Consider the vulnerability of, or potential for forced interruption of service for, a region or service area, including community water systems that provide service to the National Capital area.

(d) Disseminate, as appropriate as determined by the Administrator, to community water systems information on the results of the project through the Information Sharing and Analysis Center, or other appropriate means.

2.4 The National Strategy for Homeland Security

Published by the Office of Homeland Security in July 2002, the National Strategy seeks to "*mobilize and organize the Nation to secure the U.S. homeland from terrorist attacks.*" In a speech on July 16, 2002, the President said, "*This comprehensive plan lays out clear lines of authority and clear responsibilities...*" for federal, state, and local employees; community and business leaders; and the American public. The National Strategy identifies six critical mission areas for homeland security:

- Intelligence and warning
- Border and transportation security
- Domestic counterterrorism
- Protecting critical infrastructure and key assets
- Defending against catastrophic terrorism
- Emergency preparedness.

In addition, the National Strategy emphasizes using unique American strengths: law, science and technology, information sharing and systems, and international cooperation.

The National Strategy sets forth several roles for EPA. First, under the category of *Critical Infrastructure*, EPA is the lead agency for protecting water systems [Ref. 3, page 32]. Second, under *Defending Against Catastrophic Threats*, EPA is involved in detection of chemical and biological materials [Ref. 3, page 38], and improving chemical sensors and decontamination techniques [Ref. 3, page 39]. Finally, under *Emergency Response and Preparedness*, EPA is a participant in the National Incident Management System developed by the Department of Homeland Security (DHS), and must prepare for chemical and biological decontamination [Ref. 3, page 44].

2.5 EPA's Strategic Plan for Homeland Security

EPA's Strategic Plan describes the Agency's expanded role in responding to and preparing for national emergencies, including securing the nation's water systems, promoting security of the chemical and hazardous materials sector, and recovering from chemical, biological, radiological, or other terrorist attacks. Announced by EPA Administrator Whitman on October 2, 2002, the Agency's senior leadership prepared the EPA Strategic Plan with input from other federal agencies and organizations.

The EPA Strategic Plan outlines goals, tactics, and activity lists in four "mission critical areas:"

- *Critical Infrastructure Protection* – assessing and reducing vulnerabilities and strengthening detection and response capabilities for the water and wastewater industries as well as food, transportation, and energy.

- *Preparedness, Response, and Recovery* – strengthening and broadening EPA's emergency response capabilities, clarifying EPA's role in federal response, and developing and disseminating tools for first responders.
- *Communication and Information* – improving management and sharing of environmental information during and after chemical, biological, or radiological incidents.
- *Protection of EPA Personnel and Infrastructure* – ensuring the safety of EPA's personnel and vital infrastructure.

EPA's Strategic Plan outlines initial water security research and technical support efforts. Goal 1 under Mission Goal I (Critical Infrastructure Protection) states that "*EPA will work with the states, tribes, drinking water and wastewater utilities (water utilities), and other partners to enhance the security of water and wastewater utilities*." Goal 1 also tasks EPA to review monitoring and decontamination methods for chemical, biological, and radiological contaminants in water, wastewater, and distribution systems. This includes the development of a water utility security research plan and the initiation of priority research projects [Ref. 1, pages 3-4].

Goal 4 under Mission Goal II (Preparedness, Response, and Recovery) states that "*EPA will advance the state of the knowledge in areas relevant to homeland security to provide responders and decision makers with tools and the scientific and technical understanding they need to manage existing or potential threats to homeland security*." This includes the review, development, and testing of enhanced methods for detection, treatment, and containment of chemical, biological, radiological, and industrial chemicals intentionally introduced into water systems. Also, EPA will provide scientific and technical support to other agencies and partners [Ref. 1, pages 28-31].

2.6 National Research Council Report

The NRC report, *Making the Nation Safer: the Role of Science and Technology in Countering Terrorism*, identifies and prioritizes threats and vulnerabilities posed by terrorism, and opportunities for science and technology to play a role in counterterrorism [Ref. 15]. The report recommends research goals for nine key areas: nuclear and radiological threats, human and agricultural health systems, toxic chemicals and explosive materials, information technology, energy systems, transportation systems, cities and fixed infrastructure, the response of people to terrorism, and integrated systems analysis and engineering.

The NRC report regards water supply and wastewater systems, along with electrical supply, stadiums and other buildings, and underground facilities, as critical components of "cities and fixed infrastructure." The report discusses the key vulnerabilities of water systems, the barriers to effective mitigation of these threats, and research and development needs. Among the key vulnerabilities are the antiquated infrastructure, the ease of public access to reservoirs and distribution systems, the ease of introducing contaminants to wellheads and distribution systems, the potential for intentionally contaminated backflow, the interconnectedness of water systems (aqueducts, sewer, and wastewater lines), and the dependence on electrical and computer networks.

The NRC report makes specific recommendations related to water systems:

- Identify and implement revisions to applicable laws or statutes, thereby removing the constraints to testing public water supplies for dangerous contaminants that might be employed by terrorists.
- Take other necessary steps to assure that adequate laboratory testing capability and capacity are available to water utilities.
- Research and development to create sensors and supporting systems for monitoring the safety of drinking water. These sensor systems would continuously test the water supply for contaminants in sufficient concentrations to pose serious threats; they would signal a response site or automatically close valves.
- Research on water sampling schemes to determine what types and population of data points are required for a spatial-temporal network and on intelligent design processing to be able to reliably recognize the pattern of attack indicators versus natural hazards. Such research would require that priority attention be given to the development of simulation models

that would both analyze and simulate events and serve to train operators in systematic recovery, emergency response, and evacuation.

The NRC report identifies four high priority areas for water security research: (1) physical security of water systems, (2) monitoring and identification of chemical and biological contaminants, (3) decision models and sampling (what, when, and how to sample), and (4) interactions across infrastructures (e.g., electricity, high-pressure hydrant system). The NRC report also notes the need for creating a research center to perform risk assessment and to communicate with first responders and industry, a need partially fulfilled by EPA's NHSRC [Ref. 15, pages 245-252].

Chapter 3

Drinking Water System Protection and Security

There are many pressing drinking water protection and security issues. As depicted in Figure 3.1 and consistent with the National Research Council recommendations, projects have been developed specific to physical and cyber security, identification of water contaminants, analytical protocols, containment of contamination events, evaluation of treatment practices, decontamination and disposal of contaminated water and materials, and contingency planning. This Chapter also addresses risk assessment and risk communication, which play critical roles in supporting the risk management process prior to, during, and following a threat to, or attack on, drinking water systems.

Research and technical support needs are discussed in detail in the following sections of this Chapter. The research and technical support needs are presented in a logical sequence, rather than priority order, since all were identified as high priority in the stakeholders meeting held in February 2003. Many of these needs are being addressed simultaneously and, in some cases, projects are already underway. For each need, a list of projects to address the need is suggested.

In addressing drinking water security issues, there are overarching needs that apply to, and/or affect, all the contributing factors discussed in the sections below. Some overarching needs also cross over into wastewater protection (e.g., prioritization of contaminants, communication). Other needs are based on the impact that one system may have on the other (e.g., decontamination waste from cleaning up a drinking water contamination event will impact receiving waters, thereby necessitating a dialogue between representatives of the drinking water and wastewater systems).

The following list presents the overarching needs identified by federal partners who met with the EPA in November 2002 and stakeholders who met with EPA in February 2003 to review this Action Plan. At that time, specific projects were suggested to address the needs presented in this Chapter:

- Develop, test, and validate a protocol for the analysis of "unknowns" that is specific to drinking water supplies and systems
- Prioritize and list the most likely contaminants that could be used as threats to, or in attacks on, drinking water supplies and systems
- Develop a database that includes contaminant properties, treatability, and other data to support risk assessment
- Develop analytical methods (to address water and wastewater sampling and matrix needs) that are a prerequisite to filling gaps in the database
- Identify the most likely or "most credible" threats, including "clustered threats" (e.g., physical and contaminant-related)
- Advance on-line detectors and sensor technologies, and test those devices in realistic settings and situations
- Develop laboratory capability and capacity, especially for addressing environmental samples
- Perform table top exercises and run simulations of threats, onsets of incidents, and ultimately returning the decontaminated system to service
- Improve information sharing and communication between all involved and/or affected parties during a threat or an attack
- Provide training and education across the many stakeholders dealing with threats to or actual incidents involving drinking water supplies and systems
- Gather information and best practices from the experiences of other countries and the military in protecting their water supplies and water systems.

Where the above needs are not identified specifically in this Chapter, they will be developed as part of an overall Water Security Research Implementation Program under Chapter 5.

3.1 Protecting Drinking Water Systems from Physical and Cyber Threats

Protecting the physical and cyber infrastructure (treatment and distribution systems, source water, conveyance systems, and other remote locations) of a drinking water system requires a comprehensive approach: identifying potential threats, assessing vulnerabilities to these threats, and improving security procedures and technology to deter attacks or mitigate their impacts. As authorized under the Bioterrorism Act, EPA supports the vulnerability assessment process by providing funding and baseline threat information to community drinking water systems. Additionally, the Bioterrorism Act directs research toward addressing: (1) the physical and cyber threats most likely to be used against drinking water supplies and systems, (2) the consequences of these threats if they are actually used in an attack, and (3) the countermeasures that could be employed to prevent or respond to such attacks. Results will be used primarily by drinking water utilities, federal and state officials, and possibly emergency responders in addressing both physical and cyber threats to drinking water systems.

3.1.1 Needs and Associated Projects

a. An updated identification and prioritization of physical threats to, and vulnerabilities of, drinking water infrastructure taking into account information gained from vulnerability assessments and from other assessments of water systems and their cyber infrastructure.

b. A thorough understanding and documentation of the consequences of physical or cyber attacks on the drinking water supply sources and infrastructure, including the evaluation and testing of computational models and decision science.

c. A suite of countermeasures to prevent or mitigate the effects of physical and cyber attacks on water infrastructure, including improved design of supervisory control and data acquisition (SCADA) and water systems to reduce vulnerabilities.

a. An updated identification and prioritization of physical threats to, and vulnerabilities of, drinking water infrastructure taking into account information gained from vulnerability assessments and from other assessments of water systems and their cyber infrastructure. In response to the requirements of the Bioterrorism Act, EPA developed baseline threat information to support drinking water systems as they assessed their vulnerabilities. This baseline information outlines the major threats faced by water utilities as contemplated in early 2002. As community water systems complete individual vulnerability assessments and as law enforcement and intelligence agencies learn more about the capabilities of terrorists, the most likely threats compiled by the EPA should be reviewed and refined to reflect this additional crucial information.

Key Research or Technical Support Questions

Learning from the experiences gained by community water systems in assessing their vulnerabilities and building on EPA's assessment of baseline threat information under the requirements of the Bioterrorism Act, what are the key physical and cyber threats to drinking water infrastructure?

What can be done to minimize the physical and cyber threats to drinking water systems, including the storage of hazardous materials used as part of treatment plant operations?

How can computer-based computational models and decision science help to improve decision making and assist water utility operators in understanding threats and managing consequences from attacks?

As resources are limited for many water systems, especially small systems, what countermeasures will most effectively improve the physical and cyber security of drinking water supplies and systems?

What are the best ways to protect supervisory control and data acquisition and other computer systems used by drinking water utilities?

How can security measures be incorporated into the design of the next generation of drinking water systems or retrofitted to existing systems?

Special emphasis also should be given to identifying sources of information on the types of threats faced by the smallest water systems (serving less than 3,300 persons), since these facilities are not required to conduct vulnerability assessments. Physical and cyber threat scenarios and vulnerability assessments can be enhanced by using vulnerability information to answer questions such as: Which vulnerabilities are most apparent? Which are catastrophic? Which can be easily mitigated by cost-effective strategies and which require longer term solutions? What are the most likely categories or groupings of physical and cyber vulnerabilities? The following projects will address this need:

1. Identification of physical and cyber threat scenarios facing the drinking water sector, including a comparison of their impacts.

2. Examination and evaluation of lessons learned by drinking water utilities in assessing their vulnerabilities and in implementing countermeasures.

3. Refinement of the methodology for community water system vulnerability assessments, including evaluation of distribution systems.

b. A thorough understanding and documentation of the consequences of physical or cyber attacks on the drinking water supply sources and infrastructure, including the evaluation and testing of computational models and decision science. While the physical and cyber threats to drinking water systems are to some degree understood, the consequences of such attacks are challenging and difficult to envision. Water system components are extensively interconnected, so destruction of one component may cause a cascading effect [Ref. 15]. These consequences need to be more thoroughly understood in order for the most effective countermeasures to be employed. In addition, disruption of water service may impact other critical community sectors, such as medical services, fire fighting capabilities, and the local economy. Computational models and decision science tools provide one method to explore possible consequences from attacks that cannot be simulated accurately in an experiment or in real life. The following project will address this need:

1. Assessment of the consequences of physical and cyber attacks with an emphasis on the cascading consequences of such attacks on overall water system integrity, and compilation of technical information and tools for enhanced consequence analysis of physical and cyber threats to drinking water systems.

c. A suite of countermeasures to prevent or mitigate the effects of physical and cyber attacks on water infrastructure, including improved design of SCADA and water systems to reduce vulnerabilities. An updated understanding of countermeasures to physical and cyber threats associated with the water infrastructure is needed. In the short term, this will help the water industry prevent or mitigate the effects of such attacks. Information is needed by small water systems that may not have the resources to employ extensive countermeasures. Over the longer term, information is needed on countermeasures that have multiple benefits (e.g., enhance security and, at the same time, improve water quality or other aspects of water system operations). Such standards would take into account the “multiple benefits” aspects of revised design features since many security enhancements may not be cost-effective otherwise. Similarly, to improve security, water systems need to adopt security practices and integrate them with operational strategies as part of their routine. The following projects will address this need:

1. Working with standards-setting organizations, preparation of voluntary design standards and recommendations for new construction, reconstruction, and retrofitting with a focus on security in combination with operations.

2. Establishment of standards for minimum security protection of SCADA and other computer systems used in drinking water systems.

3. Identification of physical countermeasures that could be used by a drinking water utility to minimize threats or mitigate the consequences of terrorist attacks, including disaster response and recovery plans (e.g., shut down methods, reconstruction).

4. Assessment of existing security measures for the storage and transport of hazardous materials at water utilities and ways to improve security.

3.2 Identifying Drinking Water Threats, Contaminants, and Threat Scenarios

Knowing the contaminants that are the most likely threats to drinking water supplies or systems is critical to the Agency's efforts on research and technical support related to detection, monitoring, containment, treatment, decontamination, and disposal. EPA has undertaken an extensive effort to identify the most likely contaminants and the situations in which those contaminants could be used. This is an evolving effort that will be updated and improved as information on human health and other factors that affect a contaminant's priority are developed or discovered. Information on contaminants and contaminant surrogates/simulants will be maintained in a limited access compendium. This information will support drinking water utilities, public health officials, and responder organizations faced with threats to or attacks on drinking water supplies and systems.

3.2.1 Needs and Associated Projects

a. A manageable, prioritized list of threats, contaminants, and threat scenarios that might be used to destroy, disrupt, or disable drinking water supplies and systems.

b. A contaminant identification tool for consultation by approved individuals and organizations that describes critically important information on contaminants with the potential to harm drinking water supplies and systems.

c. A set of carefully selected surrogates or simulants for use in testing and evaluating fate and transport characteristics and treatment technologies for priority contaminants.

d. Methods and means to securely maintain and, when appropriate, transmit information on threats, contaminants, and threat scenarios applicable to drinking water supplies and systems.

a. A manageable, prioritized list of threats, contaminants, and threat scenarios that might be used to destroy, disrupt, or disable drinking water supplies and systems. A frequently reviewed and updated list of likely drinking water contaminants and associated threat scenarios is needed. As a class of contaminants, biochemicals must be better understood. Another important consideration is the potential for exposure to such contaminants through several routes, since drinking water is used for a variety of purposes in addition to consumption. Most threat assessments consider ingestion as the primary exposure route for contaminants in drinking water. This may represent only a portion of the threat spectrum as inhalation, dermal, and ocular contact should be considered as well. Understanding exposures through such secondary routes will lead to a more robust and accurate prioritization of both contaminants and threats. This is further addressed in Section 3.6. The following projects will address this need:

Key Research or Technical Support Questions
What contaminants – biological, chemical, or radiological – are threats to community drinking water systems and what is their priority in terms of health risks to drinking water consumers?
How do different contaminant-oriented threat scenarios for drinking water systems influence the health risks of these contaminants?
In addition to health risks, what are the other characteristics of biological, chemical, or radiological contaminants that may make them threats to drinking water systems?
For ensuring a safe water supply, how can water contaminants be evaluated with regard to both health (e.g., acute toxicity, lethality, long-term health impacts) and other characteristics (e.g., availability, psychological terror) to present a comprehensive picture of prioritized threats?
Once information about the most likely contaminants has been developed, how can organizations needing the information gain appropriate access to it?
What are the surrogates and simulants that best represent the prioritized contaminants for use in testing, evaluation, and verification of technologies to protect drinking water supplies and systems?

1. Preparation of a prioritized list of contaminants (and/or contaminant classes), which includes a ranking approach that allows for dynamic changes to various parameters in order to routinely generate robust prioritization of contaminants based on emerging data or concerns.

2. Identification and prioritization of contaminant threat scenarios facing the drinking water sector considering the various sizes, types, and geographic locations of utilities.

3. Development of an improved understanding of the role of biologically-produced toxins as a drinking water contaminant.

b. A contaminant identification tool for consultation by approved individuals and organizations that describes critically important information on contaminants with the potential to harm drinking water supplies and systems. After the preliminary list of contaminants is prepared and prioritized, a database of these contaminants will be developed and continually updated as new information becomes available. Databases of the effects and properties of many microbiological species and chemicals are common in the open literature. However, a database of all priority chemical, biological, biochemical, and radiological contaminants specific to water is very important, but not currently available. This database will include information on the basic properties of priority contaminants, mixtures and formulations, co-contaminants and byproducts, toxicity and health effects, and sampling and analysis methodologies. For the database to be useful in the event of a response to an emergency, users must be systematically trained to find the necessary information and to query the database. Users also should be encouraged to practice database usage by the inclusion of database searching as part of emergency response training exercises. Another important role of the database is to help the user decide if the presence of a contaminant at their location should cause a response action to be taken. In some cases, the contaminant may already be present in the background at detectable concentrations. Therefore, it is important for the database to include information on the natural background concentrations of priority contaminants for various locations. The following projects will address this need:

1. Development of a water contaminant information tool for use by individuals or organizations responding to a water contamination event.

2. Development of guidance on training approved individuals and organizations in effective use of the water contaminant information tool.

3. Development of an improved understanding of the biological, physio-chemical, and/or toxicological properties of contaminants, based on gaps in the water contaminant information tool developed under Project 1.

4. Survey of information about background levels of priority contaminants known or suspected to occur in source or treated drinking waters.

c. A set of carefully selected surrogates or simulants for use in testing and evaluating fate and transport characteristics and treatment technologies for priority contaminants. This surrogate or simulant information resource is closely coupled to information in the water contaminant information system described above. While using an actual contaminant in conducting research is preferable, this is not always possible for some potential water contaminants. In such cases, a surrogate or simulant may be used if it has properties similar to the actual contaminant relative to the specific application (e.g., type of detector or treatment train). Information on surrogates and simulants that share some characteristics with priority contaminants, but are less hazardous to work with than the actual contaminants, are of particular interest. In order for the information gathered on the surrogate or simulant to be considered applicable to the actual contaminant, the relationship between the surrogate or simulant and the contaminant being tested must be understood with respect to the particular parameters being modeled. An extremely important aspect is to determine the conditions under which a particular surrogate or simulant is not appropriate for use. This information resource is intended to provide known data and information on these relationships as well as information on the appropriateness of specific surrogates or simulants for a particular research application. Similar to the water contaminant information system, training on the use of the surrogate or simulant information resource is necessary. The following project will address this need:

1. Development of an information resource (possibly as a component of the water contaminant information tool) on surrogates or simulants for water contaminants, including relationships between the surrogate or simulant and the contaminant of interest with respect to a variety of biological, physio-chemical, and toxicological properties with guidance and training materials for approved individuals and organizations.

d. Methods and means to securely maintain and, when appropriate, transmit information on threats, contaminants, and threat scenarios applicable to drinking water supplies and systems. Lists of contaminants, potential surrogates, prioritizations, and characteristics may contain several types of sensitive or secure information. Some of this information may be publicly available, while other information may be secured with limited or restricted access. Such information might even be classified. There are cases where a collection of information may be classified, even if each individual piece of information in the collection is unclassified. This occurs because of the potential for the pooling of information to pose a threat even if the individual pieces do not. Specific decisions about the distribution of information will be made using classification procedures established by the EPA or through agreements with the information sources. Procedures will need to be established to ensure that access controls are appropriately maintained and that appropriate channels for dissemination of such information are in place. The following projects will address this need:

1. Development and implementation of a framework for evaluating the sensitivity of information and for keeping that information appropriately categorized as classified, for official use only, or available for public release.

2. Preparation of methods and means of information sharing on contaminants to ensure appropriate access by individuals and organizations based on their need for this information.

3.3 Improving Analytical Methodologies and Monitoring Systems for Drinking Water

Unlike a physical attack, the intentional introduction of a biological, chemical, or radiological contaminant into a drinking water system is not always evident. Correctly identifying contaminants after they have entered a drinking water system is extremely important, particularly when they are not apparent through general observation or conventional testing. Building a capacity and capability to respond to threats or an actual contamination event, and for restoration of systems after an event, also is essential. Accurate contaminant identification using a combination of detection technologies and analytical methods is implicit in meeting the requirements of the Bioterrorism Act; Sections 1434 and 1435 of the Bioterrorism Act [Ref. 2] both require analytical methodologies and detection techniques that can quickly and accurately provide information on contaminants.

Key Research or Technical Support Questions
What approaches, methods, and technologies can be used, in an emergency response mode, to confirm or rule out the biological, chemical, or radiological contamination of drinking water supplies or treated water?
What approaches, methods, and technologies can be used in an "early warning" mode to detect biological, chemical, or radiological contaminants in water supplies and treated water?
What are the most effective analytical tools, methods, and laboratory procedures to use in the event of biological, chemical, and radiological contamination of a water supply or water system?
What methods, techniques, and approaches are available to measure the efficacy of treatment, disinfection, and remediation approaches for biological, chemical, or radiological contamination in drinking water supplies or systems and in treated water?

3.3.1 Needs and Associated Projects

a. ***A "play book" (or module) for sampling and analytical response to contaminant threats and attacks on water supplies and systems, including protocols for identifying "unknown" contaminants that will serve as a vital component of an integrated response plan.***

b. ***New analytical hardware and associated field and laboratory analysis methodologies for biological contaminants in water, including requirements for appropriate quality assurance/quality control and sampling approaches.***

c. ***Improved analytical hardware and associated field and laboratory analysis methodologies for chemical contaminants in water, including requirements for appropriate quality assurance/quality control and sampling approaches.***

d. ***Monitoring technologies, including standard operating procedures, for biological, chemical, and radiological contaminants and threats.***

e. ***Drinking water "early warning systems" and early warning systems from other sectors amenable to application in the water environment.***

f. ***An improved and expanded, tiered laboratory capacity and capability in order to be fully prepared in responding to threats or attacks on water.***

g. ***Training exercises, drills, and simulation modules for analytical methodologies and monitoring systems.***

a. A "play book" (or module) for sampling and analytical response to contaminant threats and attacks on water supplies and systems, including protocols for identifying "unknown" contaminants that will serve as a vital component of an integrated response plan. As with any new analysis paradigm (e.g., compliance monitoring, forensic analysis, new disease outbreak investigation), the capabilities of existing methodologies to detect contamination events needs to be defined and improved. This is particularly important because the efficacy of many of the prevention, preparedness, and response technologies being developed must be tested and evaluated using reliable, standard analytical methodologies and standard operating procedures. As part of method development, the effects of sample collection, transport, worker safety, and handling on the analytical result must be considered. In addition, communication must be maintained at all stages of the response. A "play book" provides information on both the analytical methodology and detection technology that can be used in the event of a water contamination threat or actual attack.

Identification of field and laboratory capabilities and capacity for sampling and analyzing "unknowns" is a first step in providing standardized screening protocols for biological, chemical, and radiological contaminants in a drinking water system. In addition, there are general protocols developed by other federal entities to address attacks through various media (e.g., air, water, food). This effort may benefit from adapting these generalized protocols to the specific needs and requirements of drinking water systems. Such protocols must consider the capabilities of the laboratory response network that would perform an analysis of the "unknowns," and should include the need for communication between the sampler and analyst. To be most effective, once the protocols are developed and tested, they should undergo trial application by drinking water utilities and others involved in response actions. The following projects will address this need:

1. Preparation of a draft analytical response module, including decision trees, fully tested protocols, and methodical approaches, for use in addressing drinking water contamination threats and attacks.

2. Development of a protocol for the analysis of "unknowns" that is specific to drinking water supplies and systems.

3. Laboratory testing and validation of the analytical response protocol using a round-robin approach with a variety of laboratories that would be expected to provide support in a threat or attack situation.

4. End-user testing and validation of the analytical response protocol and identification of ways that it could be improved.

5. Development of an improved protocol for the analysis of “unknowns” taking into account lessons learned from Projects 3 and 4, and real-world experiences in responding to “unknowns” in drinking water.

6. Systematic updating of the analytical response module based on results from the above projects and the projects in Needs “b” and “c,” below.

b. New analytical hardware and associated field and laboratory analysis methodologies for biological contaminants in water, including requirements for appropriate quality assurance/quality control and sampling approaches. Gaps are present in both analytical hardware and analysis methodologies for biological contaminants. Sampling and analysis must be standardized and validated within a given set of parameters. A survey and summary of all available sampling, concentration, and analysis techniques (both presumptive and confirmatory) will help meet this need. An inventory of environmental monitoring methods for contaminants is currently being developed by EPA and is being extended to encompass methods applicable to specific water threats. This inventory will: (1) identify information gaps and help to focus the development of reliable methods and hardware, particularly for biological contaminants, (2) support the identification of needs for improved chemical methods, and (3) draw on the National Environmental Methods Index (NEMI) (http://www.nemi.gov). Inventory development involves collaborative funding by EPA and the U.S. Geological Survey. The following projects will address this need:

1. Development of concentration techniques and technologies for biological contaminants in water.

2. Adaptation of the NEMI to include water contaminant analytical hardware and analysis methodologies for biological contaminants.

3. Identification of water utility and response organization preferences or standards in technology design and operation for biological contaminants.

4. Development of a comprehensive understanding and definition of analysis goals, such as data quality objectives, for biological contamination events.

5. Development of standardized and validated methods for detection and identification of biological contaminants in water that might result from a contamination event.

6. Incorporation of analytical hardware and analysis methodologies from the above projects into the NEMI and the analytical response “play book” under Need “a,” above.

c. Improved analytical hardware and associated field and laboratory analysis methodologies for chemical contaminants in water, including requirements for appropriate quality assurance/quality control and sampling approaches. Currently available monitoring technologies do not address all chemical (i.e., chemical, biochemical, radiological) contaminants or contaminant categories that are water threats. Monitoring system characteristics, operational parameters, and quality assurance/quality control requirements must be identified for detection technologies used to respond to drinking water contamination events. Examples of characteristics and parameters include:

- Presumptive versus confirmatory testing
- Minimum detection limits
- Recovery and variability parameters
- Sampling, sample processing, sample transport, and analytical considerations
- Utility for forensic analysis
- Safety and security
- Integration with operations
- Commercialization.

This information can be used by technology users and developers to assess technology availability and potential applications. These requirements will help guide the analysis of potential monitoring and detection technologies. The effort will address specific principles and set achievable numeric goals. The following projects will address this need:

1. Survey, analysis, and compilation of existing analytical hardware and analysis methodologies for their applicability to water security analytical needs for chemical contaminants.

2. Development of a comprehensive understanding and definition of analysis goals, such as data quality objectives, for chemical contamination events.

3. Development and application of new analytical hardware and analysis methodologies for chemical contaminants, including radionuclides and biochemicals, based on gaps revealed through Projects 1 and 2, above.

4. Incorporation of analytical hardware and analysis methodologies from the above projects into the NEMI methods database and the analytical response "playbook" under Need "a," above.

d. Monitoring technologies, including standard operating procedures, for biological, chemical, and radiological contaminants and threats. Water system operators, scientists, engineers, and others are identifying monitoring technology needs for water contaminant threats. Technologies currently used to monitor water quality (e.g., total dissolved solids, pH, turbidity) may be adapted or "tuned" to detect contaminants. Technologies used in different applications (e.g., power industry, food industry) may have a role as well. Finally, new technologies such as the next generation of monitors may be sufficiently developed to undergo testing and evaluation. Closely associated with monitoring technology advancement, is detector performance and reliability. Any such technologies, especially ones not already in common use in the water industry, must include standard operating procedures that address:

- Specific contaminants or classes of contaminants
- Response procedures for "knowns" and "unknowns"
- Critical operational and performance features to detect contaminants before a public health exposure or effect occurs
- Specific activities and monitoring technologies to be employed in a "credible threat" event
- Monitoring procedures in response, disinfection, decontamination, and remediation phases
- Implementation of, and support for, monitoring operations
- Guidance for appropriate interpretation of results.

These standard operating procedures, along with improved monitoring technologies, analytical hardware, and analysis methodologies, will result in increased confidence in water quality. The following projects will address this need:

1. Testing and evaluation of currently used water monitoring technologies for their ability to respond meaningfully to changes in drinking water quality.

2. Preparation of a set of preliminary standard operating procedures for evaluating monitoring technologies, including the adequacy, accuracy, and usability of the set of preliminary standard operating procedures in a variety of response situations.

3. Testing and evaluation of detectors used in other sectors and in various applications for their utility to drinking water monitoring and detection.

4. Testing and evaluation of bio-sensors and biological monitors in responding to changes in drinking water quality.

5. Preparation of a set of revised standard operating procedures for use by utility operators, emergency and remedial responders, public health officials, and laboratory personnel to evaluate monitoring technologies.

6. Preparation of a handbook on currently available and emerging water security monitoring technologies that is updated periodically.

e. Drinking water "early warning systems" and early warning systems from other sectors amenable to application in the water environment. Early warning systems (EWSs) are a special subset of monitoring systems that have attracted much attention in water security. EWSs may help in responding quickly to water contaminant threats or actual attacks. A survey is needed of EWSs and their component technologies and systems for use in protecting water supplies and systems. This survey would include EWSs used in other sectors and settings that may have applicability to water. Information is needed on how specific contaminants affect the water quality parameters measured by some EWSs, particularly with regard to which EWS may best detect a contaminant. From the survey, some of the most promising EWSs would be tested at both pilot and field scale. The following projects will address this need:

1. A survey and improved understanding of EWSs that could be employed in protecting water supplies and systems.

2. Pilot-scale testing and evaluation of EWSs that could be used by water utilities to give an early warning of a contaminant threat or contamination event.

3. Field-scale testing and evaluation of EWSs that could be used by water utilities to give an early warning of a contaminant threat or contamination event.

4. Preparation of a handbook on the application of EWSs for drinking water supply and system protection.

f. An improved and expanded, tiered laboratory capacity and capability in order to be fully prepared in responding to threats or attacks on water. Based on the need to identify and network current analytical laboratories and to train laboratory personnel to assure preparedness as described above, an assessment of national laboratory capability and capacity is needed. This may involve expanding the existing federal infrastructure to provide surge capacity during an actual contamination event and its aftermath. The following projects will address this need:

1. Assessment and characterization of existing laboratory capacity and capability for drinking water sample analysis in emergency situations, and development of a laboratory compendium.

2. Determination of which laboratories are currently able, or potentially able, to run the analytical protocol developed for Section 3.3, Need "a," along with the most effective way to structure a laboratory network to assist drinking water utilities in an emergency.

3. Preparation of a gap analysis of resources (e.g., personnel, equipment), training, and methods, along with short-, medium-, and long-term recommendations to address these gaps.

4. In concert with other parts of the EPA and other federal organizations, integration of laboratories able to support emergency water analyses into an existing national network or establishment of another appropriate mechanism to meet emergency water analysis needs.

5. Development of an outreach and communication plan to facilitate inter-laboratory coordination and information exchange for water security.

6. Preparation of performance criteria for methods and infrastructure that assure adequate training of field and laboratory personnel.

g. Training exercises, drills, and simulation modules for analytical methodologies and monitoring systems. Products resulting from Needs "a" through "f" must be transferred to individuals and organizations (e.g., water utilities, response organizations) through training programs. Also, EPA and other federal organizations are developing scenarios to prepare for future threats or actual attacks. These types of exercises could easily be extended to include modules on analytical methodologies and monitoring systems by actively engaging water utilities and emergency response organizations to train personnel (or trainers). Although still in the preliminary stages, such engagements are intended to be a regular and routine part of advancing water security methodologies and technologies as they become available and ready for use. The following projects will address this need:

1. Compilation and development of training exercises and simulation modules designed to ensure the preparedness of analytical laboratories to respond to drinking water contamination events.

2. Development of training exercises and simulation modules for water utility personnel, emergency response personnel, and public health officials on the use of monitoring and

detection technologies for timely response to potential threats or actual contamination events.

3. Development of training exercises and simulation modules for water utility personnel, emergency response personnel, and public health officials on the use of monitoring systems for mitigation of potential threats or actual contamination events.

3.4 Containing, Treating, Decontaminating, and Disposing of Contaminated Water and Materials

Drinking water quality in the United States is controlled by federal regulations and guidance. These requirements are in place to assure the public that their drinking water is safe to consume. The terrorist attacks of September 11, 2001, have raised concerns that drinking water safety could be compromised by deliberate contamination of water sources and systems. The Bioterrorism Act [Ref. 2] calls for actions to prevent drinking water systems and supplies from contamination events and for ways to respond to those events should they occur. Such contamination events could result from intentional introduction of biological, chemical, or radiological contaminants into water. The concern exists that introduction of a contaminant could result in widespread dissemination of that contaminant and subsequent public exposures. If a contamination event occurs, there will need to be information and technologies available to address containing and treating the water, decontaminating both water and equipment, and disposing of residuals from any response activities.

3.4.1 Needs and Associated Projects

a. ***Improved distribution system models that can be used to more effectively protect drinking water in the event of deliberate contamination.***

b. ***An improved understanding and documentation of the environmental fate of contaminants in source waters, drinking water treatment plants, and the distribution system.***

c. ***New and more effective treatment and decontamination technologies and processes for water that has been contaminated.***

d. ***An improved understanding and documentation of decontamination and disposal of pipes, equipment, and other materials, and when a decontaminated system can be returned to safe use.***

a. Improved distribution system models that can be used to more effectively protect drinking water in the event of deliberate contamination. Distribution system hydraulic models need to be better understood and improved for use in preventing, containing, and mitigating contamination of drinking water systems. This includes an analysis of how the models can help when contaminants are injected into a water system. Commercially available and non-proprietary hydraulic models can be used to evaluate water movement in distribution systems. These models can also be used to model how non-hazardous tracer chemicals move through distribution systems. There are several large water utilities that are currently using hydraulic models for a basic understanding of their distribution system, but there is a need to determine how best to implement and use these models in medium and small water utilities.

The ability to contain a contaminant in a water distribution system will depend on: (1) how quickly the event is detected, (2) how fast the contaminant is dispersed in a distribution system, (3) how far the contaminant spreads, (4) how reactive the chemical contaminant is with residual disinfection materials, and (5) how effective residual disinfection materials are for inactivating biological contaminants. Current water distribution system models may help to answer some of these

Key Research or Technical Support Questions
What techniques and procedures should water utility, regulatory authorities, public health officials, and first responder organizations use to contain and mitigate the deliberate contamination of a drinking water system?
What is the role that computer modeling can play in understanding and tracking contaminant flow in drinking water systems?
How can contamination of water by biological, chemical, or radiological attacks be effectively mitigated and systems quickly returned to use?

questions. Additional effort is needed to determine how models can be used to establish optimum locations for in-line monitoring devices or sampling points for grab samples. By using hydraulic models, areas of high use, high flow, rapid dispersion, or other points of interest can be predicted. These points might include locations to strategically place valves or backflow prevention devices. Key distribution system endpoints also need to be evaluated, particularly to develop a better understanding of pumping devices, storage facilities, and various connections.

The capabilities of hydraulic models to effectively respond to a contamination event need to be better understood. If in-line monitoring or detection can be networked with distribution system operations, containment or direction of a contaminant within a system may be possible. Hydraulic models would show where to shut down a system, isolate the contamination to prevent it from spreading, or direct the contaminated water to an off-line storage system. Such containment would minimize exposure and facilitate cleanup. During an event where sections of a water distribution system are shut down, the hydraulic models could be used to determine how to get clean drinking water to the open sections of the distribution system. That same information would be useful in determining where in the distribution system alternative water supplies may be needed during an emergency.

During a contamination event, exposure to contaminants will depend on their concentration and the length of exposure. Determining both the concentration and time of exposure may be difficult if it is too late to sample properly. Hydraulic models can help to determine the duration of the exposure. These models may also be used to determine contaminant concentrations by running dispersion modules and reactive versus conservative reaction modules within the models. Thus, models can help to determine the need for additional cleanup, potential sites for sample collection, and the need for medical followup. Potential sites for sample collection may include low flow locations within a distribution system and models may indicate where those sites are. Ultimately, there is a need for both field and pilot test calibration methods for hydraulic models and to determine proper or standardized calibration procedures.

Another potential sampling site following a contamination event may involve point-of-use/point-of-entry (POU/POE) devices in residential or commercial buildings. Hydraulic models may show the areas where contaminant concentration and duration was sufficiently high that POU/POE devices could be assumed to have trapped some of the contaminants. Such locations can then be evaluated to determine if the POU/POE devices can provide information about the contamination event.

Hydraulic models could also be interfaced with real-time consumer complaints to indicate areas of concern. Consumer complaints are often used by water utilities to identify where problems exist. If these complaints are part of distribution system models (i.e., call location identified by geographic information system [GIS]), the data could be used to indicate geographic areas of concern. In addition, existing models can be overlain with GIS and public health data. The most effective way for these models to be used in all sizes of distribution systems also needs to be addressed.

Advancement of Water Quality Models and Their Application. The following projects will address this need:

1. Development of a water quality module extension (using EPANET as the research and development platform) that takes into account contaminant flow in distribution systems.

2. Identification and development of improved methods for hydraulic model calibration and data collection using non-hazardous tracers.

3. Development of a post-service-connection model or module to assist building owners and operators in tracking water and contaminant flow.

Development of Water Security Modeling Tools and Approaches. The following projects will address this need:

4. Development of modeling tools to harden and evaluate the vulnerability of distribution systems to intentional contamination threats through simulated threat scenarios.

5. Development of a tool to assist in confirmatory water quality sampling during emergency response to a contamination event.

6. Development of models and/or tools to evaluate decontamination strategies for water distribution systems, ranging from flushing to more innovative decontamination approaches.

7. Preparation of guides or handbooks for medium and small water systems on use of hydraulic models for distribution systems.

Development of Data Analysis Tools for EWSs. The following projects will address this need:

8. Development of data analysis tools to process on-line sensor data and consumer complaint data to determine when a contamination event has occurred.

9. Preparation of a technical resource document for using hydraulic models in locating EWS sensors.

b. An improved understanding and documentation of the environmental fate of contaminants in source waters, drinking water treatment plants, and the distribution system. The environmental fate of various chemical, biological, and radiological contaminants needs to be better understood. Of particular interest is what happens to contaminants when dispersed in source waters (e.g., rivers, lakes, ground water), water treatment plants, or distribution systems (e.g., pipelines, storage tanks). Dilution of chemical, biological, or radiological contaminants in source waters will, in many cases, reduce the concentration to below levels of concern based on dilution and treatment plant removal. This may or may not be true in the distribution system. In cases where very low levels of contaminants are toxic or aesthetically unpleasant, dilution may not provide adequate safety assurances. Also, various contaminants may attach themselves to pipe walls in a water distribution system. This could result from direct attachment to the pipe wall material, to the biofilm layer, or to the corrosion-inhibiting layers intentionally deposited on the pipe walls. A better understanding is needed regarding which contaminants may attach to the interior of the water distribution system and how they can best be removed. The following projects will address this need:

1. An assessment of the environmental fate of biological, chemical, and radiological contaminants in source waters, drinking water treatment plants, and the distribution system.

2. An investigation to determine what contaminants may attach themselves to pipe walls or to biofilms, and how best to minimize attachments on those surfaces.

3. Preparation of a technical resource document on the fate of biological, chemical, and radiological contaminants in source waters, drinking water treatment plants, and the distribution system.

c. New and more effective treatment and decontamination technologies and processes for water that has been contaminated. The ability to treat contaminants in a water system needs to be better understood. This understanding will assist in development of preventive measures, treatment of water if it is contaminated, and post-treatment disposition of contaminated water. There are some treatability data in the literature that can be used, and sparse data already exist for some biological, chemical, and radiological contaminants. Research investigating the removal of various organic and inorganic compounds from drinking water using typical drinking water treatment techniques has been extensive over the years and can be used to develop a treatability matrix for contaminants. Such a removal and inactivation treatability matrix would benefit water utilities, first responders, state and federal agencies, and the public during an event.

Different treatment scenarios for microbiological contaminants may be necessary depending on the location of contaminant introduction (e.g., into source water, into a water treatment plant, in the distribution system, or from cross-contamination). Information is needed to evaluate various disinfectants to kill or inactivate biological contaminants and the time required for inactivation in order to effectively treat contaminated water. Efforts will focus on the use of chlorine, chloramines, chlorine dioxide, and ozone, which are the disinfectants typically used by water utilities. Information will also be developed on concentration-time performance for inactivation. The disinfection data initially will be developed from bench-top studies. EPA, the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA) have some disinfection data, but information on many of the biological contaminants is still required. Information is also needed on germination techniques for contaminants that are spores; if such contaminants can be forced from the spore stage, disinfection or inactivation will be easier. Information is also needed to evaluate the impact of treatment on some chemical contaminants.

Typical water treatment practices (e.g., conventional coagulation-filtration systems, direct filtration systems, slow sand filtration systems, membrane systems, cartridge and bag filtration systems, etc.) will need to be evaluated for removal of specific microbial contaminants. Evaluation of the effectiveness of advanced treatment techniques, such as ultraviolet light and membranes, that can also provide multiple benefits is needed. Boiling tables need to be developed for biological contaminants, since time and temperature data also will be beneficial to assist the public in complying with "boil water" orders. Inactivation through exposure to elevated temperature (below boiling) for extended periods of time should be evaluated; an example is whether a home water heater holds the water for a sufficient period of time at the elevated temperature to inactivate the organisms. Such removal and inactivation data for microbial contaminants will help to put treatment techniques in place to remove contaminants from the source water, provide information to first responders, plan for cleaning up a contaminated system, and provide guidance for the ultimate disposal of contaminated water and associated wastes.

Different treatment scenarios may be necessary for chemical contaminants introduced into source water, a water treatment plant, or the distribution system. Information is needed to evaluate various water treatment techniques for their ability to remove chemical contaminants, including coagulation, lime softening, membrane, carbon, and ion exchange processes. These are typical water treatment practices that would be used at a water treatment plant to remove chemical contamination from source waters, by first responders to cleanup a contaminated system, or for disposal of contaminated water. EPA, Department of Energy (DOE) laboratories, and Department of Defense (DoD) have done work related to some of the contaminants, but data for others may be limited. Oxidation could be used to destroy some chemical contaminants, but this may also create byproducts that are harmful. Information is needed for some of the chemical contaminants to determine the effect of oxidation (disinfection) on those contaminants and what byproducts are formed.

In cases where biological, chemical, or radiological contamination occurs in a distribution system, POU/POE devices may provide the first line of defense for individuals, and these devices need to be evaluated to determine how well they remove specific contaminants. Procedures for cleaning the distribution system need to be developed. This includes understanding the best way to remove the contaminants from the interior surfaces of the various components in a water distribution system. For example, high levels of disinfectant (or alternatives to disinfectant) could be used to remove biofilm that entrapped biological contaminants, or physical scouring or surfactants may be necessary to remove attached chemical and radiological contaminants. Ultimate disposal of POU/POE devices also will need to be evaluated, and special handling and disposal needs determined, if such devices become contaminated with chemicals or radiological material.

The following projects will address this need:

1. Review of the literature for treatability information on contaminants most likely to be used to contaminate drinking water supplies and systems, including military documentation that may not be available in the open literature.

2. Preparation of a systematic method for evaluating existing and innovative treatment technology efficacy for contaminants most likely to be used in water supplies or systems.

3. Execution of bench-scale studies to determine inactivation and removal capabilities of typical water treatment and disinfection technologies for biological contaminants, taking into account various water quality parameters (e.g., pH, turbidity, temperature).

4. Execution of bench-scale studies to determine destruction and removal capabilities for typical water treatment technologies for chemical (including radiological) contaminants taking into account various water quality parameters (e.g., pH, turbidity, temperature).

5. Development of treatability documentation and a computer-driven tool for manipulating

information on the treatment of contaminants in drinking water.

6. Identification of POU/POE capabilities for treating or capturing the most likely contaminants and disposal procedures for such devices should they become contaminated.

7. Assessment of technologies for pretreating contaminated water generated from decontamination activities.

8. Identification and documentation of chemical contaminants that may create hazardous byproducts when exposed to drinking water disinfectants.

9. Preparation of a technical resource document or guide (in collaboration with wastewater expertise) for the treatment, disposal, and discharge of contaminated water or water used for cleaning contaminated pipes and equipment.

d. An improved understanding and documentation of decontamination and disposal of pipes, equipment, and other materials, and when a decontaminated system can be returned to safe use. Combining the knowledge gained from the research projects on fate and transport of contaminants (Need "b," above) and treatment processes (Need "c," above), and the projects listed below on decontamination of pipes, a recovery protocol will document effective methods for treating water, decontaminating pipes, and returning a water system to safe use. An initial version of this protocol will be developed early, with continual updates as the knowledge gaps are filled by the planned research projects.

For many contaminants, flushing the pipes or treatment of the water by chlorination or other methods may be sufficient to clean the water and the pipes. These methods will be tested, documented, and included in the protocol. However, for other chemicals (e.g., insoluble substances or those that tend to partition and attach to biofilms or adhere to pipe walls and tubercles), decontamination techniques may be necessary. The projects listed below will investigate and document effective methods for decontaminating drinking water systems through bench, pilot, and analytical studies. The data resulting from these research projects will inform water utility managers, state and federal agencies, emergency responders, and decision makers about the efficacy of decontamination methods. Research results will improve the nation's ability to respond and recover from terrorist attacks on drinking water systems, as well as accidental contamination through leaching, permeation, or backflow incidents.

The following projects will address this need:

1. Preparation of a preliminary set of standard operating procedures for decontaminating drinking water infrastructure that has been contaminated by a variety of biological, chemical, and radiological contaminants.

2. Determination of the relevant physio-chemical properties of contaminants that pose the greatest decontamination challenge for pipes and equipment.

3. Testing and evaluation of bench- and pilot-scale techniques for decontaminating distribution systems and equipment, including removal of contaminant residues from pipes.

4. Development of detailed micro-scale models of flow through pipes to evaluate fate and transport of contaminants in pipes, as well as macro-scale models to evaluate decontamination and recovery methods.

5. Demonstration of the utility of EPANET and other water quality models to plan and track a decontamination procedure for a distribution system.

6. Execution of larger or field-scale pipeline decontamination studies to determine the effectiveness of water system decontamination in a close to real-world setting.

7. Development of decontamination efficacy information and procedures for post-service connections, including small pipes and water-consuming appliances that have been contaminated.

8. Preparation of a technical resource document or guide (in collaboration with public health and remedial response expertise) for decontaminating pipes and equipment, including criteria to determine when a system is safe to use.

9. Preparation of a technical resource document or guide (in collaboration with hazardous and solid waste disposal expertise) for disposal of treatment residuals and contaminated pipes and equipment.

3.5 Planning for Contingencies and Addressing Infrastructure Interdependencies

Alternative supplies of water must be provided when drinking water systems are taken off line as the result of a physical attack or contamination event. When water delivery is disrupted, plans must be in place to provide clean and safe drinking water to customers. Traditional contingency planning approaches for providing drinking water need to be investigated, along with innovative approaches such as transportable or modular technologies that can treat water at different locations. The Bioterrorism Act [Ref. 2] calls for a review of the methods and means of providing alternative sources of drinking water. An assessment of water supply and delivery alternatives will be undertaken for various-sized systems and geographical areas, and will consider types of water sources, adjacent systems and interconnections, system redundancies, pressure source (e.g., gravity systems, pumped systems, a combination), and portable capabilities. A case study of the National Capital Area [Ref. 2] will be a key part of this review. Work is also needed to assess water infrastructure interdependencies with other critical national infrastructure, as recommended by the NRC [Ref. 16] and as described in the National Strategy [Ref. 3].

3.5.1 Needs and Associated Projects

a. An assessment and case studies of water supply alternatives for drinking water systems disrupted by contamination events.

b. Tests and evaluations of improved technologies and approaches for providing supplies of water in the event of both long-term and short-term disruptions to drinking water systems.

c. An improved understanding of water system interdependencies and the relationships of such interdependencies with other infrastructure sectors critical to national security.

a. An assessment and case studies of water supply alternatives for drinking water systems disrupted by contamination events. An assessment is needed of water supply alternatives for various system sizes in different geographic locations considering various water sources, distribution system designs, and types of pressurized delivery. The nation's drinking water utilities, particularly large utilities, often have contingency plans for alternative water supplies should portions of their systems become inoperable. Small- and medium-size systems need to be prepared for such situations as well. Such an assessment will help various-sized drinking water utilities enhance their contingency plans or develop plans if they are needed. Other benefits could also arise from planning for contingencies resulting from terrorist actions or threats. These include improved preparedness for natural hazards (e.g., earthquakes, floods, tornadoes) or accidents (e.g., line breaks, chemical tank failures). Traditional and innovative contingency planning approaches and water supply alternatives will be addressed as part of this assessment. The following projects will address this need:

1. Development of an assessment and case studies under varying situations (e.g., community water system size, geographic location) that provide a spectrum of contingency planning situations and responses (e.g., water sharing), including one specifically focused on the National Capital Area.

Key Research or Technical Support Questions
What are the methods and means by which alternative supplies of drinking water can be provided to utilities and consumers in the event of the destruction, impairment, or contamination of drinking water systems?
What are the most effective ways to secure the water sector infrastructure as it interrelates with and supports other critical infrastructure sectors in the nation?

2. Assessment of truck-mounted and otherwise portable treatment facilities that are designed for use during a crisis for areas where drinking water quality is not dependable.

3. Assessment of redundancy approaches that can be used by small, medium, and large systems to assure continuity in water supplies.

4. Systematic analysis of the use and utility of GIS in protecting water infrastructure.

5. Development of a compendium of options for providing alternative supplies of drinking water in various situations (e.g., system size and location, extent of need).

b. Tests and evaluations of improved technologies and approaches for providing supplies of water in the event of both long-term and short-term disruptions to drinking water systems. A systematic analysis and, as appropriate, further investigation is needed for new or alternative treatment techniques that use advanced technology, which might be mobile or modular. The investigation would focus on alternatives that would represent a significant advance in providing safe and clean drinking water should a water supply or system be compromised, rather than traditional contingency planning approaches. These various technological alternatives, if successful, could be added to the potential options that drinking water utilities would be able to draw upon should such be needed. The following projects will address this need:

1. Assessment of innovative technologies that specifically enable or enhance the short-term delivery of drinking water to impacted customers, as well as those that enable long-term delivery in the event of a systemic collapse of water supplies or systems.

2. Testing and evaluation of the most promising innovative technologies with an analysis of the positive features and those areas needing improvement prior to full-scale deployment in the field.

c. An improved understanding of water system interdependencies and the relationships of such interdependencies with other infrastructure sectors that are critical to national security. The interdependencies between water infrastructure and the remainder of the nation's critical infrastructure systems need to be better understood. In addition, a better understanding is needed of the reliability of systems upon which continued functioning of the water system depends (e.g., electric power, road transportation, telecommunications), including an assessment of the weakest links among the systems that are required for continued functioning. This is true for general utility-based infrastructures (e.g., electricity) that affect water infrastructure and vice-versa. Once better understood, actions can be taken to minimize the influence of these interdependencies. The DHS is responsible for protecting the nation's critical infrastructure as set forth in the National Strategy [Ref. 3], and an evaluation of how water systems affect, and are affected by, other infrastructures will have to be coordinated with DHS. Preliminary contacts have been made with DHS on a number of possible interactions, including this one. The following projects will address this need:

1. Identification and analysis of interdependencies among the nation's critical infrastructures that affect water supplies and systems in order to identify mitigation strategies and maintain water utility operations.

2. Development of guidance or a technical resource document to assist water utilities in ensuring the continued delivery of safe and clean water taking into account potential disruptions caused by other malfunctioning critical infrastructure.

3.6 Targeting Impacts on Human Health and Informing the Public about Risks

The appropriate response to water security concerns and health risks to the public is to develop tools to assess risks rapidly and reduce the uncertainties associated with rapid assessment of these risks. Section 1434 of the Bioterrorism Act [Ref. 2] calls for a review of biomedical research into short-term and long-term impacts on public health of chemical, biological, and radiological contaminants introduced into drinking water systems. By assessing human health risks from acute (i.e., 1 hour to less than 1 day) as well as short-term (i.e., 1 day to 30 day) exposures, these risk assessment tools will contribute to improved decisions on emergency response and remedial action, respectively. These tools also will help to facilitate risk communication with drinking water utility personnel, responders, and public health officials, as well as with the general public. Coupled with this rapid risk assessment approach is the need to communicate risks and associated health information between organizations and individuals who can perform the following: (1) recognize diseases or illnesses that may be related to water exposures, (2) communicate with utility personnel/managers and share information that can help in determining the extent of any risk, and (3) report the information to all affected parties so that messages on risk are clear, consistent, and accurate.

3.6.1 Needs and Associated Projects

a. ***An improved understanding of multiple routes of exposure from contaminants in drinking water supplies and systems, which should focus on generic models for different large classes of contaminants, and an improved understanding of acute and short-term exposures and chronic public health effects from contaminants in drinking water supplies and systems, which should focus on generic models for different large classes of contaminants.***

b. ***An improved communication in health surveillance to help public health officials and water utility operators rapidly identify and control a disease outbreak or other public health emergency associated with contaminated drinking water.***

c. ***An evaluation of the usefulness and validity of non-traditional data sources (e.g., lethal dose 50th percentile [LD_{50}], Quantitative Structure Activity Relationship [QSAR]) for the derivation of acute and chronic toxicity values applied to water.***

d. ***A risk assessment/risk management framework for identifying the impact of containment, decontamination, treatment, and disposal options and the subsequent response.***

e. ***Methods and means to communicate risks to local communities and to respond to customers in case of an attack on drinking water systems.***

a. An improved understanding of multiple routes of exposure from contaminants in drinking water supplies and systems, which should focus on generic models for different large classes of contaminants, and an improved understanding of acute and short-term exposures and chronic public health effects from contaminants in drinking water supplies and systems, which should focus on generic models for different large classes of contaminants. A drinking water system can be contaminated with a single contaminant or a complex mixture of contaminants. The contaminant(s) can be introduced into a water supply system at various locations and through a series of events and mechanisms. The possible widespread distribution of a contaminant can result in the exposure of a relatively large population and may result in an adverse health effect, which depends on either the minimum infective dose or the potential dose of the biological or chemical contaminant, respectively. The severity of the effect(s) depends on who is exposed, exposure duration and media concentration, and this could result in sickness and in some cases death. Consumers are not the only group of individuals

Key Research or Technical Support Questions

What are the risk-related questions that need to be addressed following a threat or actual attack on a drinking water system?

What are the components of a rapid risk assessment protocol for drinking water that has been contaminated with biological, chemical, or radiological contaminants?

What are the most likely pathways of exposure for individuals who come in contact with contaminated water supplies or treated water?

What are the acute, short-term, and (when appropriate) chronic longer-term effects from exposure to contaminants in water supplies or treated water?

What are the desired decontamination levels that would minimize health risks to responders and drinking water customers?

What types of information should be communicated for water threats and attacks and how can this information best be conveyed to targeted organizations, individuals, and the general public?

that could be exposed to the contaminants. Individuals working for a water utility or emergency responders also may be exposed and, therefore, are at some risk of an adverse effect.

The traditional exposure route for contaminated drinking water is ingestion. This is not the only route, as some contaminants may result in exposures via inhalation, dermal, and ocular routes. The following projects will address this need:

1. A compilation of a comprehensive, readily-modified database on the acute, short-term, and chronic non-cancer health effects associated with the priority contaminants.

2. Evaluation of all possible routes by which people might be exposed to contaminated water and an analysis as to the likelihood or viability of these routes for exposure.

3. Development of an easily updated and secure information portal on exposure routes and public health effects associated with various threat scenarios to water supplies and treated water.

4. Critical review and assessment of various methods or models (e.g., QSARs), as well as other available information and scientific judgments regarding the toxicity or infectivity of the priority contaminants to estimate reference and infective doses.

b. An improved communication in health surveillance to help public health officials and water utility operators rapidly identify and control a disease outbreak or other public health emergency associated with contaminated drinking water. Early detection of water-borne contamination, whether accidental or intentionally introduced, is the primary goal of a health surveillance system. CDC has the capability to develop a health surveillance monitoring network. A network of this type, coupled with information from drinking water utilities, will provide both the capability and capacity for real-time surveillance of water quality. Since tracking morbidity is a late indicator of risk, some earlier indicators are desirable. Syndromic surveillance is one example that may be useful to indicate increased illness, disease, or death related to waterborne contaminants. For example, supermarkets and druggists track sales of over-the-counter antidiarrheal medications as an early indicator of *Cryptosporidium* outbreaks. Another potential avenue for early warning of illness or disease is an enhanced role for poison control centers.

If a water contaminant causes a "notifiable disease," health surveillance systems may detect this. Through EPA collaboration with agencies such as CDC, FDA, and state/local health departments, input to surveillance systems may be improved, and a linkage may be developed between existing health surveillance systems with water utility data. This would help to determine whether a disease or illness outbreak is caused by a water contamination event within a system or utility.

Another area where risk assessment tools and the appropriate risk communication approach can be helpful is in the surveillance and warning of increased disease and illness reported by physicians and hospitals. The following projects will address this need:

1. Collaboration with CDC, FDA, and state/local health departments to evaluate existing health surveillance networks to rapidly detect and control a disease outbreak by more effectively linking public health and water system information and data.

2. Development of a technical resource document or guide to assist water utilities, public health officials, and other organizations in instituting a program for tracking disease outbreaks associated with water contamination events.

c. An evaluation of the usefulness and validity of non-traditional data sources (e.g., LD_{50}, QSAR) for the derivation of acute and chronic toxicity values applied to water. The evaluation of a contaminant involves the identification of its hazards through the collection and generation of relevant toxicity data. These data can be used to: (1) identify the most sensitive indicator of toxicity, (2) provide information on the dose-response relationship, and (3) estimate the no-observed-adverse-effect-level (NOAEL) [Ref. 17]. Many of the contaminants of interest do not have a complete toxicity data set. Therefore, LD_{50} data must be used instead of NOAELs to estimate acute toxicity values for particular contaminants. Use of single point toxicity estimates such as LD_{50} values and structure-activity relationships to project acute toxicity values for human populations is a difficult concept and one that will require significant validation. Some models do exist (e.g., MCASE, TOPCAT, DEREK3, PALLAS). The DoD's Armed Forces Medical Intelligence Center recently concluded that QSARs are less well developed for acute toxicity than for chronic toxicity. QSAR methodologies have been developed for many longer-term toxicology endpoints, such as cancer, reproduction, and neurotoxicity. The following projects will address this need:

1. Preparation of a methodology for extrapolating LD_{50} data to derive toxicity values for biological, chemical, and radiological contaminants that are threats to drinking water supplies and systems.

2. Preparation of a methodology for using QSARs to estimate toxicity values for priority chemical contaminants that are threats to drinking water supplies and systems.

d. A risk assessment/risk management framework for identifying the impact of containment, decontamination, treatment, and disposal options and the subsequent response. The proactive integration of risk management and risk assessment will pose many challenges in responding to terrorist threats or attacks. Any attempt to address risk must consider both assessment and management in order to be most useful to a number of stakeholders. In particular, when responding to a contamination event, the responders or remedial managers must know the risk management options for minimizing exposures to the public. In an emergency situation, the risk management option(s) might determine: (1) the protocols used to evaluate the chemical, biological, and radiological contaminants, (2) the approach used in conducting the risk assessment, and (3) the method and means of communication that will be used to convey the risks to various groups. The following projects will address this need:

1. An analysis of current approaches to and procedures for integrating risk assessment and risk management decision making in order to quickly respond to threats and attacks with information for on-scene decision makers from threat notification through threat response.

2. Testing and refinement of approaches and procedures through the application of simulations, table top exercises, and information applications that involve risk assessment and risk management integration.

3. Development of a test protocol for use by risk assessors and risk managers in addressing threats and attacks on drinking water supplies and systems as part of improved consequence management.

e. Methods and means to communicate risks to local communities and to respond to customers in case of an attack on drinking water systems. When a threat or attack occurs, fast and effective communication on risks is essential. No one method or means will be appropriate for all places or times. Knowing what tool to use, when, and how can only be determined through communication planning and research. Information developed in advance can be distributed to the appropriate people as needed. Releasing appropriate information in a timely fashion can build trust and may moderate the public response in the event of an actual attack or a hoax. Efforts to educate the general public in understanding and preparing for potential threats is critical to effectively prevent and/or respond to an event incident. Mechanisms to achieve such needs have to be developed based on open communication between all affected parties. The following projects will address this need:

1. Adaptation of a preliminary risk communication framework that can be used to respond to threats or attacks on drinking water systems.

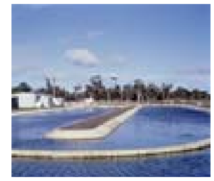
2. Preparation of information, materials, and model protocols prior to an actual threat or event that can facilitate early response to customers facing concerns about their drinking water.

3. Development and stocking of a repository where prepared information and materials can be maintained and retrieved for use, when and if the need arises, in response to a threat or attack on drinking water supplies and systems.

4. Development of a refined risk communication framework that ensures access to appropriate individuals and organizations so they are well prepared to respond to threats or attacks on drinking water systems.

Chapter 4

Wastewater Treatment and Collection System Protection



Wastewater systems, like drinking water systems, have been identified as a part of the nation's critical infrastructure. The wastewater treatment and collection infrastructure requires additional measures for security and protection from a variety of high potential threats and attacks. This Chapter on protecting wastewater systems parallels Chapter 3 on drinking water by describing needs in a number of key areas. While there are many similarities and interdependencies between drinking water and wastewater security issues that will benefit from a sharing of information and tools, there also are some significant differences as described below.

A clearer understanding of the threats faced by wastewater systems is needed, including a thorough assessment of the health and safety risks that could result from the misuse or intentional introduction of hazardous substances at wastewater facilities. Needs for improving system design are described in this Chapter, as is the use of intrusion protection technologies for wastewater treatment systems. Finally, this Chapter identifies security-related needs for prevention, response, and communications at wastewater facilities. For each need, a list of projects is presented to address the need, and the projects are presented in order of priority. The research and technical support needs are presented in a logical sequence, rather than priority order, since all were identified as high priority in the stakeholders meeting held in February 2003. Many of these needs will be addressed simultaneously and, in some cases, projects are already underway for many of the needs.

This list of overarching needs and projects was essentially confirmed and further developed by wastewater stakeholders who participated in the WERF wastewater security symposium in August 2003. The projects identified in Section 4.1 incorporate the combined input from all of these meetings. In addressing wastewater protection, there are overarching needs that apply to both drinking water and wastewater security and protection. Examples include, but are not limited to, physical and cyber security and contaminant identification. Other needs underscore the interdependency between drinking water and wastewater systems based on the impact that one system may have on the other (e.g., intentional contamination and subsequent decontamination of drinking water systems can significantly impact the operation of downstream wastewater facilities).

Key Research or Technical Support Questions
Building on experience already gained by wastewater utilities, what are the high priority threats to the nation's wastewater infrastructure and the potential consequences of those threats?
What countermeasures can be undertaken to best prevent, contain, or mitigate attacks on the wastewater infrastructure?
What enhancements can be made to monitoring and surveillance systems, technologies, and security measures to protect the wastewater infrastructure?
How can security measures be incorporated into the design of the next generation of wastewater systems, or retrofitted to existing systems?
What is the critical information that wastewater utilities need in order to most effectively prepare for and respond to potential threats or actual attacks?

4.1 Needs and Associated Projects

a. ***A thorough understanding and documentation of the possible threats to the nation's wastewater treatment and collection system infrastructure, including the interdependencies with drinking water systems and other critical infrastructure.***

b. ***An updated assessment of the possible health, safety, and environmental risks related to potentially hazardous substances used by wastewater utilities or produced during response to security threats (e.g., decontamination materials and their byproducts) or intentionally introduced into wastewater collection and treatment systems or stormwater conveyance and treatment systems, including any impact on residuals management operations (e.g., sewage sludge).***

c. ***Improved intrusion monitoring and surveillance technologies to quickly notify wastewater utilities when these facilities or technologies are compromised by physical or cyber threats or chemical, biological, and radiological contaminants.***

d. ***Improved designs for wastewater systems to reduce vulnerability to physical threats and as a way to prevent or mitigate the effects of attacks on wastewater infrastructure.***

e. ***Enhanced prevention and response planning methods, including emergency response (e.g., relocation of discharge or alternative treatment), contingency planning, and risk communication protocols and guidance for wastewater systems of varying types (size, geographic location, design).***

f. ***Methods and means to securely maintain and, when appropriate, transmit information on contaminants and threat scenarios applicable to wastewater systems.***

a. A thorough understanding and documentation of the possible threats to the nation's wastewater treatment and collection system infrastructure, including the interdependencies with drinking water systems and other critical infrastructure. To more fully prepare for threats or attacks on the nation's wastewater collection and treatment systems, additional work is needed to more thoroughly identify and prioritize possible threats and threat scenarios. For example, treatment chemicals that are potentially hazardous to human health and the environment, if workers or the surrounding community are exposed to them, are an area of particular interest. Attention needs to be given to "unattended operations" (e.g., pumping stations, small treatment plants with limited staff) and the possible risk to the health and welfare of the general public. The following projects will address this need:

1. Identification and prioritization of potential physical, cyber, and contaminant (e.g., biological, chemical, radiological) threats and threat scenarios for the nation's wastewater treatment and collection infrastructure, including consequence analysis of adverse events.

2. Assessment of countermeasures or system redundancies that could be employed for the most likely threats and threat scenarios.

3. Evaluation of "unattended operations" and how they can best be protected from physical, cyber, and contaminant threats and attacks.

4. Improved understanding and assessment of the critical linkages and interdependencies between drinking water and wastewater systems, and how these linkages directly impact human health and safety as well as the operation and performance of the wastewater system.

5. Identification and analysis of interdependencies between critical infrastructure that affect, or are affected by, impacted wastewater systems to maintain operations and to promote the development of prevention, mitigation, and response technologies.

b. An updated assessment of the possible health, safety, and environmental risks related to potentially hazardous substances used by wastewater utilities or produced during response to security threats (e.g., decontamination materials and their byproducts) or intentionally introduced into wastewater collection and treatment systems or stormwater conveyance and treatment systems, including any impact on residuals management operations (e.g., sewage sludge). Depending on the specific setting, the intentional contamination of wastewater could result in harmful exposures to chemical, biological, or radiological hazards. Chemical, biological, or radiological contaminants that pass in and through wastewater treatment plants can subsequently have deleterious effects on downstream waters, operations, and related infrastructures. On-site use of hazardous chemicals for disinfection and other purposes is common at wastewater utilities, and presents a unique hazard to both human health and system operations. The following projects will address this need:

1. Preparation of a "Baseline Threat Document" for wastewater systems that is analogous to the drinking water baseline threat document.

2. Screening level risk assessments of biological, chemical, and radiological contaminants that could be used as contaminant threats in wastewater treatment plants and collection systems using currently available risk assessment tools.

3. Comparative assessment (including associated risks) of alternatives to conventional disinfection that use chlorine, including the byproducts that may result from such alternatives.

4. Evaluation of wastewater treatment technologies that either currently or through enhancement can more effectively remove contaminants introduced into or received by wastewater collection systems, including consideration of safe handling of contaminated wastewater.

5. Evaluation of intentionally introduced biological, chemical, or radiological contaminants on sewage sludge and other residuals associated with wastewater treatment.

c. Improved intrusion monitoring and surveillance technologies to quickly notify wastewater utilities when these facilities or technologies are compromised by physical or cyber threats or chemical, biological, and radiological contaminants. The challenge of maintaining wastewater system integrity must be combined with a vigilant program of monitoring and surveillance. Protecting wastewater systems and discouraging intrusion using physical protection technologies will achieve a high degree of threat reduction. Using various real-time monitoring and intrusion detection devices that can immediately recognize the introduction of harmful chemical, biological, or radiological contaminants can provide timely alerts and trigger critical response actions. Additional surveillance devices could be identified and adapted or developed to complement those already available for wastewater system applications. Similar to the needs identified for drinking water systems, sensor technologies for wastewater systems also are needed to monitor water quality for chemical and biological contaminants that have been identified as threats to wastewater systems, or would compromise the protection to human health and the environment provided by these systems. The following projects will address this need:

1. Development and assessment of information on current practices and methods to control intrusion of wastewater collection systems and other components of the wastewater infrastructure (including combined systems and storm water systems), which could be used to gain access to critical community targets.

2. Assessment of existing and new technologies and systems (i.e., commercially available) for use in sensing physical threats to and contaminant introduction into wastewater collection and treatment systems, including toxins that could disrupt wastewater treatment processes.

3. Testing, evaluation, and verification of intrusion monitoring and surveillance technologies and systems, as well as their ability to provide timely notification of physical attacks or contamination events on the wastewater collection and treatment systems. These efforts would include current bioassay methods for detection and identification of contaminants, and use of intelligent monitoring and control networks.

4. Assessment of currently applied wastewater/storm water/combined sewer outflow models for simulating the movement of dangerous/hazardous materials in wastewater collection systems.

5. Assessment and dissemination of information on technologies and methods for developing continuous monitoring and control systems for wastewater/storm water collection systems for

dangerous levels of volatile, explosive, and toxic gases.

6. A thorough identification and analysis of potential threats to computerized and automated controls and other SCADA systems associated with wastewater collection and treatment systems, and the means to protect them from cyber attacks.

d. Improved designs for wastewater systems to reduce vulnerability to physical threats and as a way to prevent or mitigate the effects of attacks on wastewater infrastructure. An updated understanding of threats to wastewater infrastructure and the consequences of attacks will facilitate the development of guidance for the wastewater industry on methods to prevent or mitigate their effects. The following activities will aid in prevention and mitigation: (1) developing prevention or mitigation countermeasures based on specific threat scenarios, and (2) working with standards-setting organizations to develop design standards and recommendations for new construction, re-construction, and retrofitting with a focus on security (e.g., optimal levels of redundancy to main continuity of critical operations). An important consideration in developing revised design standards for wastewater systems is to recommend measures that have multiple benefits (e.g., enhance security and, at the same time, improve wastewater system operations). Without consideration of "dual-use" aspects of revised design features, many security enhancements may be relatively expensive, which could limit their adoption by wastewater utilities and the design community. The following project will address this need:

1. Working with standards-setting organizations, preparation of voluntary design standards and recommendations for new construction, reconstruction, and retrofitting with a focus on security in combination with improved operations.

e. Enhanced prevention and response planning methods, including emergency response (e.g., relocation of discharge or alternative treatment), contingency planning, and risk communication protocols and guidance for wastewater systems of varying types (size, geographic location, design). Vigilant surveillance and reliable protection technologies greatly increase the security of wastewater collection and treatment systems. However, the health and safety of the general public also relies on carefully developed emergency response and contingency plans. For example, when monitoring and surveillance systems alert wastewater utilities of a possible breach of security, immediate response actions must be triggered. Carefully developed risk communication messages provide the necessary information to the media and the general public to make informed decisions while minimizing panic or concern. In addition, educational materials developed to help the general public understand and prepare for potential threats are key elements of effective prevention and response plans. Additional work can be undertaken in these areas to enhance measures already in place. The following projects will address this need:

1. Development of response protocol "play books" for use by all key participants to create their own "game plans" in responding to wastewater collection and treatment system threats or attacks.

2. Preparation of a wastewater system table top exercise to guide, and an accompanying case studies resource document to encourage, interaction among wastewater system organizations and to provide them with insight and experience in role-playing threat scenario

3. Improvement of risk communication tools (with the public, individuals, and organizations) for those personnel and organizations responsible for protecting wastewater collection and treatment systems and/or responding to threats or attacks.

f. Methods and means to securely maintain and, when appropriate, transmit information on contaminants and threat scenarios applicable to wastewater systems. Lists of contaminants, potential surrogates, prioritizations, and characteristics may contain several types of sensitive or secure information. Some of this information may be made available to the public, while other information may have to be secured with limited or restricted access. The need for limited or restricted access may result from the source of the information, the nature of the information, or the potential for harm from widespread release. Specific decisions about the distribution of information will be made using classification procedures established by EPA or through agreements with the information sources. Procedures will need to be established to ensure that access controls are appropriately maintained, and appropriate channels for dissemination of such information will need to be created and utilized. The following projects will address this need:

1. Evaluation of existing methods and means of information sharing on wastewater threats and contaminants, including the feasibility of a dynamically updated database, to ensure appropriate access to individuals and organizations based on their need for this information.

2. Based on consideration of critical knowledge management issues, development of a framework for evaluating the sensitivity of information related to wastewater systems, and addressing needs identified in Project 1, above.

Chapter 5
Implementing the Action Plan

EPA will implement this Action Plan with the help of a number of organizations in order to get the most accurate information quickly and efficiently to those who need it. To this end, the Water Security Team at the NHSRC is working closely with the WSD in the Office of Water to advance research collaborations, provide technical support, improve technology readiness, and disseminate timely and targeted information on water security. Chapters 3 and 4 of this Action Plan describe what needs to be done for drinking water and wastewater, respectively. This Chapter describes how it will be done.

5.1 Collaborative Research and Technical Support

The WSD and NHSRC are working together closely to address water security needs through this Action Plan. This is a collaboration involving numerous partners and stakeholders. Both the Office of Water and ORD have conducted discussions with many organizations who are critical in the execution of this Action Plan. Close collaborations are underway with the American Water Works Association Research Foundation and WERF on research and technical support projects related to drinking water and wastewater, respectively. Work is underway with the American Society of Civil Engineers on designing physical security into future water and wastewater infrastructure projects.

Relationships have been developed between EPA and other organizations with expertise in many of the project areas. Such relationships (e.g., Memorandum of Agreement [MOA], Memorandum of Understanding [MOU]) allow for formal working relationships across federal organizations, including the means to transfer funds through Interagency Agreements (IAGs). Examples include partnerships with the Department of the Army's Edgewood Chemical Biological Center in Edgewood, Maryland; the Department of the Air Force's Air Force Research Laboratory in Dayton, Ohio; the FDA Forensic Chemistry Center in Cincinnati, Ohio; the U. S. Army Corps of Engineers' Civil Engineering Research Laboratory in Champaign, Illinois; DOE's Argonne National Laboratory in Chicago, Illinois; and DOE's Sandia National Laboratories in Albuquerque, New Mexico. Discussions are underway with the CDC in Atlanta, Georgia, and the National Institute of Science and Technology in Washington, DC. In addition, EPA is working with two directorates in DHS (the Science and Technology Directorate, and the Information Analysis and Infrastructure Protection Directorate) to address water issues, needs, and projects.

Various EPA Offices and Regions are also collaborating in the water security arena. The EPA Regions are involved in implementing this Action Plan through the WSD. Other EPA Offices engaged in addressing homeland security that directly or indirectly relate to water security are the Office of Solid Waste and Emergency Response; the Office of Prevention, Pesticides and Toxic Substances; the Office of Air and Radiation; and the Administrator's Office of Homeland Security. In addition, collaboration with the water sector in implementing some of the needs and projects presented in this Action Plan will continue.

5.1.1 Distribution System Research Consortium

EPA has formed the Distribution System Research Consortium (DSRC), comprised of 14 partnering organizations. The DSRC is an EPA-led national umbrella organization made up of member federal agencies and water organizations dedicated to the advancement of science, technology, and research to protect drinking water distribution systems from terrorist attacks. The DSRC accomplishes this mission by:

- Collaborating to advance science, technology, and research in the following areas:
  - Monitoring and Detection
  - Early Alert and Warning Systems
  - Models and Modeling of Systems

- Treatment of Waters in Systems
- Decontamination of Equipment and Materials.

- Identifying challenges and prioritizing the development of short- and long-term solutions to expedite the implementation of useful and feasible distribution system technologies.
- Transferring information (through EPA communication mechanisms and via other routes such as the WaterISAC) and assisting drinking water utilities, states, researchers, policy makers, risk assessors, public health community members, and others needing research results or guidance on the security of distribution systems.

5.2 Technology Advancement through Testing, Evaluation, and Verification

An integral part of the Agency's water security program involves advancing water security technologies and determining their readiness for implementation. It is important for water system utility operators and the public to know whether these technologies, which are at various stages of development, are reliable and ready for use. Chapters 3 and 4 of this Action Plan describe many drinking water and wastewater needs and projects, some of which involve detection, monitoring, containment, treatment, decontamination, and disposal technologies. Many technologies are being offered to water system operators, and many more technologies are being advanced that technology developers or vendors hope will be commercial successes.

The WSD provided funding to expand the EPA Environmental Technology Verification (ETV) Program to validate sensors and biomonitoring technologies, POU/POE devices, and decontamination water treatment technologies in August 2002. The NHSRC has continued to support these efforts with funding in 2003. Advancing water security technologies will occur in a number of ways:

- Convening vendors and users in forums (e.g., homeland security technologies development forum) where technology vendors address user needs in an open, fact-based interchange on needs and capabilities.
- Offering vendors (that have demonstrated proof-of-concept up through a first- or second-generation prototype) an opportunity to advance their technology through an accelerated and competitive Small Business Innovation Research Program.
- Engaging with the Office of Water and the DoD Technical Support Working Group (TSWG) to advance technologies through TSWG's broad agency announcements for technology advancement.
- Offering vendors a site, or sites, where they can bring their fully-prototyped technologies for controlled or more real-world testing assisted by EPA (e.g., EPA Water Awareness Technology Evaluations Research and Security Center, National Environmental Technology Test Sites) using Cooperative Research and Development Agreements.
- Offering vendors (that have commercially ready technologies) an opportunity to undergo verification through the EPA's ETV Program.
- Establishing a national clearinghouse for technology users to access information on water security technologies and to facilitate more informed decisions when selecting technologies for use [Ref. 18].

The above options are being employed to address technology advancement as part of this Action Plan. They are proven approaches from the standpoint of being accepted ways of doing business to advance environmental protection technologies in other EPA programs, and they can all be used to meet the urgent needs of technology advancement for water security.

5.3 Information Sharing

One of the overarching issues of homeland security communication is the proper dissemination of information. The Bioterrorism Act [Ref. 2] stresses information sharing as follows:

> *Section 1435(d) – Information Sharing: ...the Administrator shall disseminate, as appropriate as determined by the Administrator, to community water systems information on the results of the project through the Water Information Sharing and Analysis Center (Water ISAC) or other appropriate means.*

A variety of organizations and individuals may be involved along the continuum of prevention, preparedness, and response to a threat to or an attack on a water system. They also are potential users of the water security research and technical support products that are developed under this Action Plan. As either the NHSRC or the WSD produce new information under this Action Plan, all of the potential users must be considered and information provided appropriately.

5.3.1 Information Users

A variety of organizations and individuals will need information that is developed under this Action Plan to make more informed decisions on prevention, preparedness, and recovery in the case of a threat to or actual attack on a water system. Table 5.1 presents some examples of information users, but there are other potential users that may not yet be identified. As with several aspects of this Action Plan, the information users listed in Table 5.1 and how they are targeted to receive information will evolve over time. The method of information dissemination will be determined, in part, based on the level of sensitivity of the information presented, and distribution will follow processes established by EPA.

5.3.2 Information Products

The types of information sharing products provided will depend on the research or technical support subject matter, the end user of the information, and how quickly it is needed. Types of products may include response guides, technical notes, contaminant-specific advisories, technology bulletins, technical reports, workshop presentations, seminars, training sessions, newsletters, mathematical models, response protocols, procedures, peer-reviewed journal articles, risk communication products, web broadcasts, and secure or open-source databases.

5.3.3 Information Dissemination Methods

A listing of all available research products, as well as many of the products themselves, will be placed on NHSRC's Web site at http://www.epa.gov/ordnhsrc. An internet-based catalog with publicly available products from both WSD and NHSRC will be located on the WSD Web site at http://www.epa.gov/safewater/security.

Table 5.1. Potential Users of Research and Technical Support Information Developed Under This Action Plan

Water Industry Representatives	State, Regional, and Local Response Organizations
Drinking water and wastewater facility owners and operators National/state level drinking water and wastewater associations	State water administrators and authorities State and local law enforcement Fire departments National Guard Emergency planning officials and committees State/municipal elected and appointed officials
Public Health Officials and Organizations	**Federal Agencies and Departments**
Centers for Disease Control and Prevention Agency for Toxic Substances and Disease Registry Public health agencies Public health professionals Medical practitioners and medical support personnel National/state public health associations	EPA Regional and Headquarters Offices Department of Homeland Security Federal Bureau of Investigation Federal Emergency Management Agency Central Intelligence Agency U.S. Army Corps of Engineers
Laboratories with Water Sample Testing Capabilities	**Academia and Consulting Firms**
Federal laboratories (including EPA) State public health and environmental laboratories Municipal laboratories Commercial laboratories	Academic researchers Consultants Engineering, scientific, and public health associations
Elected Officials and the Public	
Media Elected officials	General public International organizations and entities

Dissemination mechanisms for sharing information developed under this Action Plan may include a variety of traditional media and venues, such as industry conferences and poster sessions, peer-reviewed journals, and workshop presentations. When information is sensitive, dissemination mechanisms may include secure or limited-access information exchanges (e.g., WaterISAC [Ref. 13]).

How EPA will handle sensitive information that is developed under this Action Plan will evolve. The Administrator has classification authority, and levels of delegation below the Administrator are still being considered. In preparing and distributing information from this Action Plan, the EPA NHSRC and security policies that guide disclosure of sensitive data will be followed. A variety of media and venues may be used to ensure that the most relevant information is made available to stakeholders in a timely fashion. Whereas traditional publishing and e-publishing are suitable media for distribution of general information on most technologies, it may be necessary to use more secure means of communication, with classified networks being the most secure, to disseminate highly sensitive information.

Chapter 6
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