

EPA's Water Security Modeling and Simulation Research

Helping Water Utilities Provide Clean, Safe Drinking Water through Advanced Computer Technology



Water distribution networks deliver drinking water to consumers through a system of pipes, valves, pumps, and tanks. These networks are vulnerable to accidental or intentional contamination.

Detecting contamination in distribution networks is difficult because of the spatial extent of the systems, rapid flow rates, and

natural variability in water quality. In addition, distribution systems are looped, resulting in mixing, dilution, and spread of contaminants. The water industry needs technology that can rapidly identify the presence of contamination in distribution systems and guide decisions that minimize public health and economic impacts and restore service to customers.

As part of U.S. EPA's Office of Research and Development, the National Homeland Security Research Center (NHSRC) provides products and expertise to improve our nation's ability to respond to environmental contamination caused by terrorist attacks on our nation's water infrastructure, buildings and outdoor areas.

NHSRC conducts research related to:

- Detecting and containing contamination from chemical, biological, and radiological agents
- Assessing and mitigating exposure to contamination
- Understanding the health effects of contamination
- Developing risk-based exposure advisories
- Decontaminating and disposing of contaminated materials

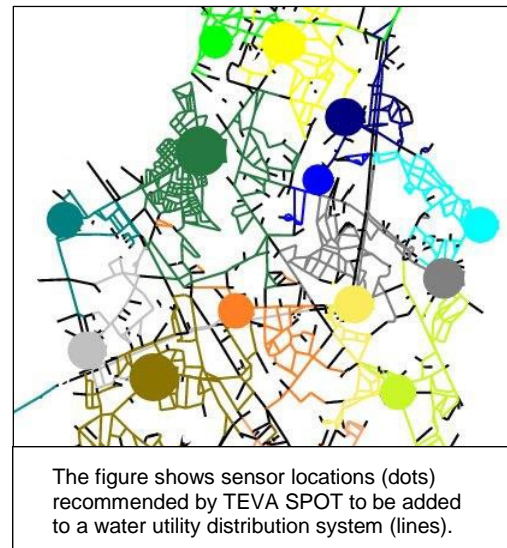
EPA's Water Security Modeling and Simulation Research Program is developing technological innovations to meet the needs of the water industry. The program is providing tools to help the water industry throughout the continuum of a water contamination incident: rapidly detecting and interpreting changes in water quality, evaluating different response scenarios, and assessing how best to decontaminate a distribution system. The program has released three software tools and has plans to release additional tools. Available products include TEVA-SPOT (Threat Ensemble Vulnerability Assessment Sensor Placement Optimization Tool), CANARY Event Detection Software, and EPANET-MSX (a Multiple Species eXtension to the EPANET hydraulic and water quality software). EPANET-

RTX (a Real-Time eXtension to EPANET) is currently being piloted. A response and decontamination toolkit is being developed and assessed for feasibility and sustainability.

TEVA-SPOT

TEVA-SPOT is used by water utilities to optimize the number and location of contamination detection sensors so that economic and/or public health consequences are minimized. TEVA-SPOT is interactive, allowing a user to specify the minimization objective (e.g., the number of people exposed, the time to detection, or the extent of pipe length contaminated). It also allows a user to specify constraints.

For example, a TEVA-SPOT user can employ expert knowledge during the design process by identifying either existing or unfeasible sensor locations. Installation and maintenance costs for sensor placement can also be factored into the analysis. TEVA-SPOT has been piloted to design sensor networks for the five cities participating in EPA's Water Security Initiative.



CANARY Event Detection Software

CANARY enables water utilities to use water quality sensors for indicative parameters (e.g., free chlorine, total organic carbon, and electrical conductivity) to indirectly detect contamination incidents. The software uses mathematical and statistical techniques to identify the onset of abnormal water quality patterns.



Drinking water utilities use the software in conjunction with a network of water quality sensors to rapidly detect contamination and to more accurately assess when and how they need to respond. The software distinguishes between natural variations in water quality and unnatural variations that point to likely contamination, and it sends an alarm when water utilities should investigate and respond. In addition to achieving homeland security goals, CANARY can be used to detect operational problems such as sensor failure or pipe breaks. CANARY was recognized as one of the top 100 new technologies of 2010 by R&D Magazine. It has been running continuously for more than two years at two large water utilities.

EPANET-MSX

EPANET is a widely used computer program for modeling water flow and quality in drinking water pipes. Its water quality component, however, is limited to tracking a single chemical species. In the real world, chemicals and biological organisms react with substances in the water and on the pipe walls. EPANET-MSX was developed to model the complex interactions of multiple reaction species, thus providing a more realistic prediction of water quality in a distribution system. EPANET-MSX enables users to model reactions of interest to water utility operators such as chlorine loss, the formation of disinfection byproducts, nitrification dynamics, disinfectant residuals, and adsorption to pipe walls. Homeland security researchers are particularly interested in modeling the fate and transport of toxic contaminants in drinking water distribution systems.

EPANET-RTX

Real-time modeling integrates hydraulic and water quality models with real-time field data to provide the ability to forecast, hind-cast, and estimate current conditions at any point within a distribution system. These conditions include such things as system pressures, flow rates and water quality. The ability to accurately identify conditions in a distribution system and predict conditions given different operational or contamination scenarios will help utilities meet operational, emergency response, and water system planning goals.

A survey of members of the American Water Works Association indicated a high interest in the ability to model in real time, and that many utilities will have the capability to use such software.

Water Security Toolkit

The Water Security Toolkit (WST) is a suite of tools that help provide the information necessary to make good decisions resulting in the minimization of further human exposure to contaminants, and the maximization of the effectiveness of intervention strategies. WST assists in the evaluation of multiple response actions in order to select the most beneficial consequence management strategy. It includes hydraulic and water quality modeling software and optimization methodologies to identify:

- sensor locations to detect contamination,
- locations in the network in which the contamination was introduced,
- hydrants to remove contaminated water from the distribution system,
- locations in the network to inject decontamination agents to inactivate, remove or destroy contaminants, locations in the network to take grab sample to confirm contamination or cleanup and

- valves to close in order to isolate contaminated areas of the network.

Summary

The Water Security Modeling and Simulation Research Program is developing products to help water utilities detect contaminants and respond to incidents. The software tools are free to the public under an open-source license and are made available via the EPA website (www.epa.gov/homeland-security-research). In addition, several research and technical assistance reports are available on this website to assist users.

Contact Information

Technical Contacts:

Terra Haxton (haxton.terra@epa.gov)
Robert Janke (janke.robert@epa.gov)
Regan Murray (murray.regan@epa.gov)

General Feedback/Questions: [Kathy Nickel](mailto:nickel.kathy@epa.gov) (nickel.kathy@epa.gov)