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Wastewater Security

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If one were to ask the "man or woman in the street" about security and water quality, it is likely that he or she would be able to explain on some level the potential danger associated with contamination of the drinking water supply. Indeed, even before the tragic events of September 11, 2001, President Clinton issued Presidential Decision Directive PDD 63, which designated the water infrastructure along with several other classes of infrastructure as "critical." The U.S. Environmental Protection Agency (EPA) was designated as the lead agency for the water sector and is responsible for developing plans to improve water infrastructure security. The significance of potential vulnerabilities to wastewater infrastructure are less immediately obvious but potentially as catastrophic. This article explains the basis of security concerns for wastewater infrastructure, discusses current practices in the area of wastewater vulnerability assessment and mitigation, and highlights efforts to expand the knowledge base of this emerging area.

Background

Contingency planning for extreme events has long been standard practice for designers and operators of wastewater and stormwater infrastructure. For decades, good practices have required consideration of the potential impact of severe natural events, including floods, hurricanes, blizzards, and earthquakes. These possibilities have been included both in wastewater and stormwater infrastructure design and in emergency preparedness and disaster response planning. The potential consequences of vandalism and employee misconduct may also have been considered. Today, there is a new focus of concern: the possible effects of intentional acts by domestic or international terrorists.

As a result, forward thinking wastewater systems are assessing and mitigating their vulnerabilities to this new area of concern. These systems are, however, challenged by the fact that water and wastewater security is an emerging area of practice that has evolved over just the last two years. Fortunately, rapid progress has been made in expanding the knowledge base required to secure wastewater infrastructure. The EPA, water and wastewater associations, utilities, and other institutions have worked together to identify and address areas of need. In many cases, practices and tools from other sectors for which security has been a long-term concern are being adapted to water and wastewater security. Finally, focused research is being used to fill data gaps and address wastewater-specific issues.

This is, nevertheless, an area of challenge for owners and managers of wastewater infrastructure. Currently, the assessment and mitigation of vulnerabilities is voluntary. Unlike water systems, wastewater and stormwater systems are not facing mandatory requirements (see below). Wastewater systems are, however, faced with other legal requirements and other pressures, including the challenges associated with maintaining aging infrastructure that also requires substantial investments. As a result, water and wastewater utility managers must balance external demands for security measures with the internal resources to develop and finance improvements.

Overview of Wastewater Treatment Systems

Wastewater infrastructure consists of the collection, conveyance, sewer, and treatment system. The collection system is comprised of a network of pipes, conduits, structures, devices, and appurtenances for the collection, transportation, and pumping of wastewater. Some of the underground structures, particularly those intended to contain stormwater following heavy rainfall, can be quite large. While much of the collection system is underground, some essential components (e.g., pumping equipment) are above ground. There are three basic types of sewers: sanitary, storm, and combined. Sanitary sewers contain domestic, commercial, and industrial wastewater, which is conveyed to the treatment plant. Storm sewers contain only stormwater and other runoff, which usually goes directly to a water body, such as a river or stream. Combined sewers are typically located in older metropolitan areas and are used to collect both wastewater and stormwater, which is conveyed to the treatment plant. Typically wastewater and stormwater flows through the collection system under gravity or a combination of gravity and pumping, depending on topographic conditions.

Figure 1 shows the sequence of the unit processes used at a typical wastewater treatment plant in the United States. During preliminary treatment, the first step in the process, large debris and a varied assortment of undesirable solids (e.g., grit, sand, and rags) and other components are removed using screens, shredding devices, grit removal systems, and possibly chemical addition. Preliminary treatment is followed by primary treatment (sometimes termed primary clarification), where gravity is used to separate and remove suspended and floating material. In the secondary treatment phase, biological treatment is used to decrease the concentration of dissolved, colloidal, and suspended organic material in the wastewater. The most common process, the activated sludge process, utilizes aerated biological reactors or tanks containing an established mixed population of microorganisms in the presence of oxygen and trace amounts of nutrients for treatment. Secondary treatment also involves secondary clarification, where solids generated by the process are removed and sent to solids handling. The liquid separated by this clarification step may be subject to further chemical, physical, or biological treatment (advanced treatment) and will very likely be disinfected to destroy pathogenic organisms before discharge. The most common disinfection agent is chlorine. Other systems use sodium hypochlorite, ultraviolet radiation (UV) or ozonation. Because the solids settled or otherwise removed during wastewater treatment are unstable and contain pathogenic organisms, they must be treated before disposal. This solids treatment is also a multi-step process. The first two steps are thickening (volume reduction by removal of water using a variety of processes and equipment) and stabilization (anaerobic or aerobic biological processing or chemical treatment to decrease levels of volatile materials and pathogens). Dewatering, composting, or thermal drying follow. The solids are then disposed of by either burial in a landfill; beneficial reuse (e.g., as a soil amendment); or incineration.

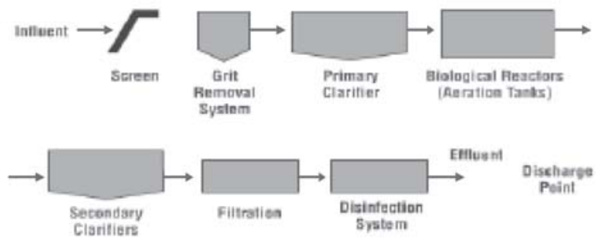

Figure 1 Flow Diagram for Wastewater Treatment Plant

Assessing Wastewater System Vulnerabilities

On June 12, 2002, President Bush signed the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (PL 107-188) into law. This Act requires community water systems serving populations of greater than 3,300 to conduct and submit to EPA vulnerability assessments and to develop or upgrade emergency response plans. All of these water systems were required to assess and report on their vulnerabilities by June 2004. Although legislative initiatives have been introduced (e.g., S. 1039, The Wastewater

Treatment Works Security Act), there is currently no mandatory requirement that these be conducted.

There are unique security concerns related to wastewater and stormwater infrastructure, and a specific vulnerability assessment methodology has been developed to address these concerns. This methodology, the Vulnerability Self Assessment Tool or (VSAT™), is a software program developed by the Association of Metropolitan Sewerage Agencies (AMSA). It provides a structured approach for utilities to assess vulnerabilities and identify countermeasures to reduce risks. The methodology was subsequently adapted for combined water and wastewater utilities and is available free. More information is available at www.vsatusers.net. The Water Environment Federation (WEF) has been conducting free training workshops on conducting vulnerability assessments with this tool. Information on these sessions is available at www.wef.org/watersecurity.

Vulnerability assessment methodologies for the water/wastewater sector are now well-established. In addition to VSAT™, some wastewater utilities are utilizing RAM-W (Risk Assessment Methodology–Water), which was developed by Sandia National Laboratories and the American Water Works Association Research Foundation (AwwaRF), to conduct vulnerability assessments. Combined water/wastewater utilities and stand alone wastewater utilities of various sizes are working to identify and prioritize security concerns, conduct vulnerability assessments, and develop security plans.

In the past, vulnerability assessments have typically been used for facilities such as nuclear or chemical plants where the physical assets are usually centralized and have likely been laid out with security concerns in mind. Wastewater and stormwater physical infrastructure are often highly dispersed geographically which presents challenges for ensuring their protection. Furthermore, concerns regarding collection systems can involve their potential to provide unrestricted access to government buildings, financial centers, hospitals, and other sensitive targets. Large diameter gravity sanitary, storm, or combined sewers could be accessed via manholes, inlets, or overflow structures.These systems are large enough to allow individuals using them to pass undetected beneath city streets. Another specific concern relates to the potential for destruction that could occur if highly flammable or explosive substances are introduced into the wastewater collection system of a major metropolitan area. The level of destruction that has resulted from accidental releases has been significant, including destroying streets and buildings within the vicinity of the explosion. Historical accounts of accidental releases of flammable or explosive materials being deposited into wastewater systems substantiate the potential for widespread devastation from an intentional act.

There are specific concerns related to the wastewater treatment as well as collection systems. Interruption of the wastewater treatment process, for example, by the introduction of substances toxic to the microorganisms in the treatment process, can shut down treatment for some time, potentially causing sewer backups and/or overflows. This can lead to widespread environmental and public health impacts, with subsequent economic impacts and an erosion of public confidence.

For drinking water systems, contamination water has been identified as the highest priority important security concern, and it is the subject of a considerable amount of research and development. Much of this research is focused on “early warning systems.” Early warning systems will be designed to rapidly detect contamination events in drinking water systems, with the goal of avoiding or significantly reducing the most serious consequences of such an event. The concerns for intentionally introduced toxic substances in wastewater systems are different in many ways than those for drinking water systems and offer a unique set of detection challenges. However, there are certain parallels between the reliable detection of intentionally introduced toxics in wastewater and drinking water systems that will provide mutual benefits through continued research and development. The benefits of research and development on early warning of potentially disruptive toxic occurrences in wastewater systems will be improved process control both in “routine” operations, and in the event of a terrorist attack.

Hazardous chemicals used and stored at wastewater treatment plants could be used by terrorists or vandals in acts of sabotage. Chlorine can be of particular concern, and some systems in sensitive locations have elected to discontinue its use. However, a recent survey conducted by the WEF does not suggest that this practice is widespread. Nearly 300 wastewater treatment plants in the US responded to the survey conducted in late 2003, and about 40% reported using chlorine gas for disinfection. About one third of respondents indicated that they were considering a change in disinfection practices. Of these facilities, over 60% cited regulatory or safety concerns as the reason, while only 5% cited security concerns as the main reason for a change (WEF 2004).

The information technology systems of wastewater utilities may also prove to be vulnerable. Most modern facilities include supervisory control and data acquisition (SCADA) systems–many designed to completely replace manual operation of a facility. Hacking into these systems could be used to cause overflows or interrupt treatment processes causing back-ups. The Water Environment Research Foundation (WERF) is responding to these concerns with a project to provide guidance to utilities on how to secure and protect computerized and automated systems using currently available technologies to sense and correct security breaches. Initial findings from this work should be available to wastewater utilities in early 2005.

Identifying and Prioritizing Threats To Wastewater Systems

As more wastewater utilities have begun to perform vulnerability assessments, the need for guidance on which threats to consider during this process has been identified. This type of guidance has been available to water utilities for some time. EPA, under the direction of Congress, developed a Baseline Threat Document that provides water utility security teams with a way to identify the most relevant threats for their facility. EPA emphasizes that the document was not designed as an exclusive list of threats for a utility to consider and that the utility team should meet regularly with law enforcement personnel, public health agencies, and other stakeholders in the community to develop a site-specific threat listing for their vulnerability assessment. Nevertheless, water systems have found the guidance valuable and wastewater utilities are seeking a similar resource. EPA and WEF are working jointly to develop similar guidance for wastewater utilities. This guidance should be available late in 2004.

Reducing Vulnerabilities

Many utilities have found that changing operational practices can be a very cost-effective way of decreasing vulnerabilities. This requires training to build awareness and reinforce good practices such as consistent use of employee/contractor badges, pass codes, locks, and so forth. Rigorous chain-of-custody procedures should be used for the acceptance of chemical deliveries. Employees should be trained to identify and respond to suspicious behavior or to recognize indications of the presence of biological or chemical contamination. All employees should be aware of the existence of the facility's emergency response plan and what they should do in the event that it is activated. Regular drills and tabletop exercises can be helpful, and liaison with local emergency responders is essential. Some wastewater utilities are reaching out to local law enforcement personnel who may be unfamiliar with the nature of the operations and materials at the site. USEPA Region 1 has developed a poster and a visor card that water treatment facilities can use to educate their local police and the tips provided via these products may also be helpful for wastewater systems. Copies of these materials can be obtained at http://www.epa.gov/safewater/security/flyers/index.html. Samples of materials useful for public outreach and for distribution to the news media are also available at this address. It is important that every facility identify a single, trained spokesperson to communicate to the media should an event occur. Messages must also be coordinated with public health authorities to ensure that the information disseminated to the public is consistent and clear.

Wastewater systems are becoming aware of the need to locate and secure critical business documents and records, including "as-built" drawings, procurement records, legal documents, and a detailed contact list of customers and employees. Some of these records may be deemed sensitive in nature, and access to them will be controlled. Others may prove to be essential in ensuring a utility keeps running in the face of a threat. These "knowledge base assets" need to be organized and securely maintained. In some cases, copies should be made and kept off-site.

Other Areas of Development

Wastewater utilities have unique concerns related to the disposal of residues from the cleanup of chemical, biological, or radiological incidents. Wastewater systems may be asked to accept decontamination residues or contaminants may be washed into wastewater or stormwater systems by storm events or by emergency-response personnel during an incident. Treatment plant managers are seeking guidance on how to treat or dispose of these residues. EPA is working with AMSA to develop guidance for wastewater utilities on the safe handling and disposal of contaminated wastes. These contaminated wastes could result from a direct attack on the wastewater system or from a contamination/decontamination event on another target in the system's service area. The guidance will better prepare wastewater utilities to effectively address worker safety, impacts on their treatment systems (including biosolids), and public health and environmental concerns. Progress on this study will be reported at http://www.amsa-cleanwater.org/advocacy/security/.

The Water Environment Research Foundation is working on a number of projects some of which are in collaboration with AwwaRF. The projects cover a range of issues, including guidance to utilities on how to interact with the public, develop contingency plans, or evaluate "hardening" options (physical security measures). Other projects address specific technological applications, such as methodologies and technologies to identify, screen, and treat chemical, biological, and radiological contaminants in wastewater. The previously mentioned guidance for utilities on securing computerized and automated systems also is a collaborative effort of WERF and AwwaRF.

Finally, designers and managers of wastewater treatment systems have expressed a strong need for peer-reviewed information on best security practices for wastewater and stormwater system design, operation, maintenance, retrofit, and upgrade. Water Environment Federation (WEF) is developing consensus guidance materials that address how to include security and emergency response considerations into the design, construction, operation, and maintenance of wastewater collection and treatment facilities and stormwater systems. Considerations regarding minimizing effects of natural disasters are also being addressed, and this guidance will help systems of all sizes lower security risks and improve emergency response. Size-appropriate approaches and cost considerations will be identified to address specific security concerns. It is anticipated that a draft will be available late in 2004. WEF is working on this project in partnership with the American Water Works Association (AWWA), which is focusing on developing similar guidance materials for water utilities and the American Society of Civil Engineers (ASCE), which, in turn, is focusing on "methodologies and characteristics," such as contaminant and flow modeling.

The wastewater/stormwater security guidance materials will reflect a consensus evaluation of sound security-related practices. Examples of design considerations to be addressed include system redundancy and back-up, location and hardening of mission-critical assets, and design of hazardous materials storage/handling systems. Operations and maintenance guidance will also cover a wide range of issues from employee screening and training; working with the public; coordination and outreach with local emergency response personnel; use of sensing and detection equipment, etc. Some of these measures, though considered in the context of security and emergency response requirements, will also have a positive impact on facility performance. For example, as previously mentioned, use of advanced sensing technology may allow for more effective process control as well as an enhanced capability for the early detection and identification of toxic substances. Special emphasis is being given to identifying and developing measures that will have "multiple benefits" as a means to increase the likelihood that utilities will invest in security enhancements. Once the project is complete, the three project partners (ASCE, AWWA, and WEF) will consider developing consensus industry standards based on the guidance materials.

Research Needs

The current efforts described here should go a long way toward making wastewater systems more secure and better prepared for a variety of adverse circumstances. Both EPA and WERF have undertaken efforts to identify additional security needs faced by wastewater systems. In 2002, EPA initiated a process to identify drinking water and wastewater research and technical support security needs. EPA's process relied on stakeholder input from the outset and resulted in a final "action plan" in early 2004. WERF conducted a wastewater security symposium in the summer of 2003 that produced a prioritized research agenda that also was published in early 2004. Both the EPA and WERF efforts identified a very similar set of research needs. The top two needs identified by WERF are development of security-related design standards for wastewater and stormwater facilities, and guidance on the safe handling of contaminated materials and treatment residuals. Efforts to address these concerns are already underway. The other highest priority needs identified by WERF include: addressing interdependencies with other critical infrastructures that could adversely affect wastewater systems; demonstration of ways to detect contaminants of concern in wastewater systems; and information on physical security measures for wastewater systems.

Conclusions

While the issue of security is new to the wastewater sector, experience dealing with the impacts of natural disasters and accidents on these vital treatment systems has helped prepare utility managers to cope with this new issue. Awareness of the issue of security is growing, though managers must balance competing pressures for scarce resources within their systems. New tools that are being developed and research that is being advanced have and will continue to strengthen the basis for sound decision-making.

Author Bio and Contact Information

Eileen J. O'Neill is Managing Director for Technical and Educational Services with the Water Environment Federation. In this capacity she oversees WEF staff with responsibility for the technical content of WEF conferences, workshops, and training courses; surveys of municipal and industrial practice; training materials including in print, video, CD-ROM, and web formats; and technical support to WEF's committees. Dr. O'Neill oversees various projects in the areas of utility management and security. She has almost 25 years experience and holds a B.S. in Soil Science from the University of Newcastle-upon-Tyne (UK) and a Ph.D. in Soil Science from the University of Aberdeen (UK) and undertook a postdoctoral traineeship in Environmental Toxicology at the University of Wisconsin at Madison. Her area of interest is the fate and transport of contaminants in the environment.

Alan Hais is a Senior Environmental Engineer with EPA's National Homeland Security Research Center. Mr. Hais serves as the EPA headquarters coordinator for water and wastewater security research, and has the lead for EPA research on wastewater security and physical security of water systems. Mr. Hais has more than 30 years experience with EPA's water programs. He has served in various technical and management positions, specializing in municipal wastewater treatment technologies and standards, drinking water regulations and ambient water quality criteria. Mr. Hais also worked for the District of Columbia on the design and operation of the Washington's Blue Plains Wastewater Treatment Plant. He received bachelors and master's degrees in civil/environmental engineering from the University of Maryland and is a registered Professional Engineer.

References

Water Environment Federation. 2004. Disinfection Process Survey Summary, *Water Environment & Technology* 16(7).