THE UNTAPPED MILITARY DRINKING WATER SURVEILLANCE RESOURCE

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ABSTRACT

Should terrorists attack U.S. drinking water, many researchers have speculated that consumers will be the first to detect it. In the absence of a "real-time" drinking water monitoring system, water utilities must focus on using more conventional water quality indicators as a measure of drinking water safety. Consumer complaints are one of the most valuable water quality indicators to the industry, because consumers are at every point in the distribution system at all times. One major advantage of consumer complaints is that consumers contact the water utility and file complaints when their water quality changes. As a result, military installations must review, revise and establish effective consumer complaint handling procedures to ensure that the consumer information is incorporated into the early-warning system.

INTRODUCTION

Unintentional and intentional drinking water contamination could completely cripple a U.S. military installation. Hundreds of people could become sick and the contamination could also result in numerous deaths. Such an event would also generate a great deal of media attention and would most likely be broadcast nationally and internationally. Furthermore, consumer confidence in the ability of the installation to protect the populace from a terrorist attack would greatly decrease.

In response to elevated terrorist threats, many military installations are searching for guidance on how to develop better drinking water monitoring systems. While an "all-inclusive" sensor that alerts the utility about the presence of chemical, bacteriological and radiological contaminants has not been developed, water utilities must focus on using more conventional water quality indicators as a measure of safety (reference 13). Measuring disinfectant residual concentration, water pH and turbidity, and testing for coliform bacteria are several recommended actions.

Fortunately for the military, the presence of many drinking water contaminants affect drinking water aesthetics (i.e., tastes and odors) and can be detected by consumers. In some cases, consumers have demonstrated that their sense of smell rivals detection levels of highly expensive analytical instruments by detecting some chemicals at nanogram per liter levels (ng/L or 10^{-9} g/L).

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For example, an inadvertently opened valve at a Connecticut water treatment plant diverted fluoride into a city water supply (reference 7). Because of this event, drinking water consumers ingested fluoride and copper at concentrations 40 times greater than normal. Many of the consumers who ingested this water contacted the water utility and reported clinical symptoms such as severe nausea, vomiting, diarrhea, abdominal cramping and skin irritation. Other consumers that contacted the water utility complained that their water had an abnormal taste or that it turned blue on contact with soap. These consumer complaints were effective in alerting the Connecticut water utility that there was a problem and prompted the water utility to investigate. Many U.S. Army water utilities, similar to this example, have also found that consumer complaints are good indicators of drinking water contamination (reference 12).

From a health surveillance standpoint, drinking water consumer complaints are the untapped surveillance resource. Drinking water consumers act as "real-time" water quality sensors that provide feedback to the installation and these consumers are located at every point in the distribution system at all times. Unlike distribution system chlorine residual concentrations that must be measured by a utility operator, consumers carry out the entire water evaluating and reporting process. Recognizing these advantages, consumer complaints should be integrated into the drinking water early-warning system on each military installation.

Unfortunately, consumer complaints are not effectively handled at most military installations. The main problems at installations are: (1) they do not designate one organization responsible for all complaints, such as the directorate of public works; (2) they do not have any official standard operating procedure, or (3) have not been given any complaint handling guidance. This paper discusses consumer complaint handling benefits and procedures in more detail. More complaint handling guidance can be obtained by contacting the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), Water Supply Management Program (WSMP).

CONTAMINANTS OF CONCERN

Many public health officials have expressed concerns that terrorists may attempt to contaminate drinking water with chemical and biological warfare agents. While such an attempt to disrupt water plant operations is possible, a high level of expertise is required to obtain, transport and dose these hazardous chemicals and biological agents. More likely, terrorists will contaminate drinking water using common chemicals such as industrial solvents, pesticides, and herbicides.

Water suppliers are fortunate that water containing most chemical agents has noticeable characteristics, such as taste and odor, and also affects clarity and color. Water with these characteristics makes it highly likely that consumers will reject the water as safe and file a complaint (reference 8). Aesthetic attributes of several of the most prevalent chemical warfare agents are provided in Table 1 (references 6, 8 and 10). Of the chemicals in Table 1, cyanide has historically received a large amount of notoriety as a chemical that can be used to contaminate drinking water (references 4 and 5).

Cyanide has been used for thousands of years as a drinking water poison and has recently been found in the possession of terrorists (reference 4).

Table 1. Aesthetic Characteristics of Water Containing Chemical Warfare Agents

Compound Name	Taste Descriptor	Odor Descriptor	Color Descriptor	Turbidity Present (Yes/No)
Tabun (GA)	Not Reported	Fruity	Colorless to brown	No
Sarin (GB)	Not Reported	Odorless	Colorless	No
Soman (GD)	Not Reported	Fruity, camphor	Colorless	No
VX	Not Reported	Odorless	Colorless to straw-colored	No
Lewisite (L)	Not Reported	Geranium, obnoxious	Colorless	No
Sulfur mustard (H or HD)	Not Reported	Garlic, mustard, obnoxious	Pale yellow	Yes
Nitrogen mustard (HN)	Fishy	Fishy	Colorless	No
Cyanogen chloride (CK)	Sharp, biting, metallic	Pepperish	Colorless	No
Hydrogen cyanide (AC)	Bitter, metallic	Almonds, marzipan, peach kernels	Colorless	No

Other chemical poisons suspected to be used by terrorists are industrial chemicals, pesticides, herbicides and insecticides. These chemicals are easier to obtain and transport than the chemical agents. Many of the chemicals that are easily acquirable have associated odors. Also, ingestion of these chemicals at acute concentrations would result in consumers experiencing negative health affects (i.e., nausea, vomiting, and diarrhea).

Public health officials have speculated that the most likely biological agent choices are botulinum toxin and *Cryptosporidium*. While biological agents have not been found to cause objectionable tastes, odors or colors in the drinking water, they are similar to chemical agents in that following ingestion, consumers will experience discomfort or even more severe health effects as shown in Table 2 (references 2 and 3).

Table 2. Ingestion Symptoms of Microbiological Contaminants

Contaminant	Disease	Microorganism	Clinical Symptoms
E. coli 0157:H7	Dysentery	Bacteria	Diarrhea, abdominal pain, bloody stools
Vibrio cholerae	Chloera	Bacteria	Diarrhea, rapid dehydration to a state of collapse
Cryptosporidium paruum	Cryptospoidiosis	Protozoan	Nausea, diarrhea, and stomach cramps
Giardia lamblia	Giardiasis	Protozoan	Nausea, diarrhea, bloating, headache, stomach cramps, weight loss
Norwalk virus	Viral gastroenteritis	Virus	Nausea, vomiting, diarrhea, fever

COMPLAINT SYSTEM ELEMENTS

Military installations must ensure that all consumer complaints are being handled effectively, efficiently, and expeditiously. Failure to do so could result in public health concerns. Furthermore, failure to document each complaint prevents the installation from being able to review a past complaint if a chronic health problem ever arises.

To better prepare installations to handle a terrorist attack event, integral parts of a consumer complaint handling system must be in place. The following discussion provides the reader with the preferred structure.

- *Senior Personnel Oversight:* Appropriate supervisory personnel from the water system operation and maintenance, environmental management, and preventive medicine should oversee the complaint handling system. Oversight includes reviewing frequent complaint database reports and follow-up actions.

- *Single Point-of-Contact (POC):* A single POC is the most critical aspect of a consumer complaint handling system. Without a single POC, multiple organizations may investigate the same complaint and previous complaint experience is not utilized. Most importantly, early detection and timely response to a contaminated water incident would fail to occur.

- *Consumer Education:* Installation water systems should make consumers aware of where to call and encourage them to report any water quality or supply problems. Awareness can be accomplished through articles or advertisements in installation newspapers, in-processing information packages, and Consumer Confidence Reports (CCRs) (reference 11).

- *Established Procedures:* Consistent and effective procedures for handling complaints should be used at military installations. Procedures should be adopted at the installation for receiving a complaint, for conducting a field investigation, for requesting minimum laboratory analyses, and for coordinating follow-up actions. The above-mentioned procedures are discussed in more detail in the following complaint handling guidance procedures section of this document.

- *Complaint Database/Log:* One complaint electronic database/log per installation should be developed. This information will be helpful to investigators when responding to future complaints. Furthermore, this database will be helpful in identifying any chronic water quality problems such as locations of low chlorine residual concentrations in the distribution system.

RESPONSE, TRACKING AND MAPPING

Effective consumer complaint procedures used at drinking water treatment plants around the U.S. are described below. Figure 1 shows the overall consumer complaint decision process. These processes are described in more detail in the draft USACHPPM Technical Guide (TG) entitled *Drinking Water Consumer Complaints* (reference 9).

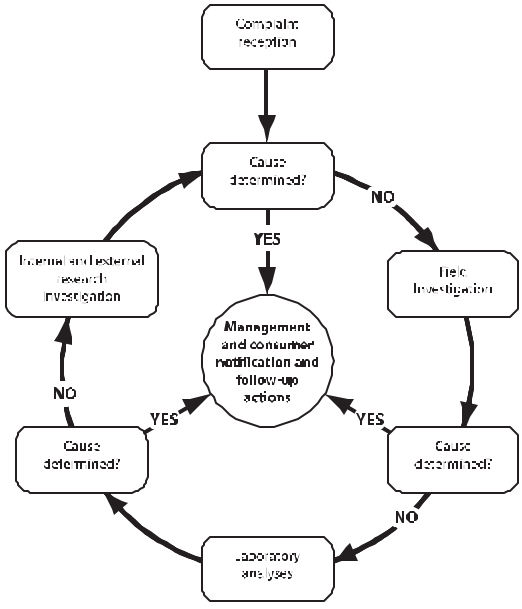

Figure 1. The Consumer Complaint Decision Wheel.

Receiving a Complaint

Obtaining basic information from the consumer is one of the most important parts of the investigation process. A standard, installation-specific form, similar to those provided in the draft USACHPPM TG (reference 9) should be used when taking a complaint. The following baseline information should be obtained:

- The consumer's full name and telephone number
- The building address where the complaint is being noticed
- The room and/or tap (i.e., faucet, sink, or shower) where the suspect water is being detected, and an accurate description of the problem (i.e., taste, odor or appearance)
- The occurrence frequency and duration of the water quality problem (i.e., 1 day, 3 weeks)

Military installations should ensure accurate documentation and mapping occurs. Documentation, especially electronic, is extremely useful to investigators as it provides a background of previously filed complaints. As Figure 2 illustrates, by mapping the consumer complaints, the installation can determine if the water quality problem is isolated or widespread on the installation. From this map, emergency responders and installation managers can also estimate the number of consumers affected and determine the location of the contaminated water and system valves.

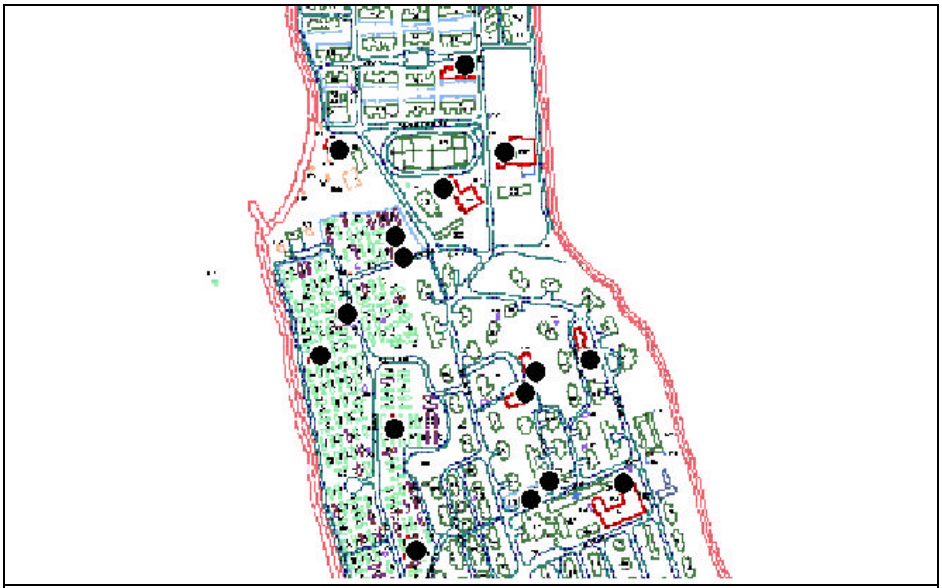

Figure 2. Map of the XYZ Water System Showing the Spatial Location of Consumer Complaints. The darkened circles indicate the location of one consumer complaint. Data recorded over 24 hours.

Field Investigation

All of the sample containers used during the field investigation must be clean and free of any residuals (i.e., dirt and liquid). Residuals can impact the water quality analysis. Containers provided by consumers are usually not acceptable. Water stored in plastic milk cartons should be evaluated for only visual quality. Plastic milk cartons have been known to impart tastes and odors. If the complaint investigator conducts an on-site visit, water samples should be collected for bacteriological analyses. Table 3 shows additional recommended on-site field water quality analyses for consumer complaints.

Table 3. Recommended On-Site Field Water Quality Analyses

Measurement Type	Required	Preferable
Water pH	X	
Water temperature	X	
Disinfectant residual concentration (i.e., free and combined chlorine)	X	
Bacteria analysis [1]	X	
Turbidity	X	
Conductivity		X
Describe appearance (i.e., clarity and color)	X	
Describe taste[2]	X	
Describe odor[2]	X	

1. The investigator should take one 1 Liter water sample for coliform bacteria analysis.
2. The investigator should use their best judgment to determine if measuring this parameter is safe.

Pertinent Laboratory Analyses

If intentional contamination is suspected or the cause of the consumer complaint cannot be identified or solved during the on-site visit, water samples should be sent for analyses at a qualified laboratory. This laboratory should be certified for conducting drinking water analyses. Appropriate laboratory analyses should at the minimum include the methods listed below:

- Coliform bacteria
- Conductivity
- Color
- Metals to include copper, manganese, iron, and zinc
- Common aesthetic water quality analysis: flavor profile analysis Standard Method 2170, or the threshold odor number test-Standard Method 2150 (reference 1)
- Additional guidance for the selection of pertinent analyses is provided in the draft USACHPPM TG (reference 9).

Internal and External Research Investigation

If results from field and laboratory testing do not reveal the cause of the consumer complaint, more investigative work is required. Complaint investigators should then conduct an internal investigation of the water utility to determine if there are any operational abnormalities. This includes reviewing any recent records or actions that may have affected the drinking water. Some utility-moderated events that can affect water quality include: startup or shutdown of treatment processes; changes in treatment processes; main breaks; fire fighting activities; distribution system flushing activities; storage tank painting, and construction near waterlines. External research investigations may also be helpful. These could include contacting local hospitals to determine if the illness reported is more widespread. This type of crosscheck will link the drinking water consumer surveillance system with the syndromatic surveillance system.

Management and Consumer Notification and Follow-up Actions

Managers and concerned consumers should be informed about the suspected cause of the undesirable water characteristic noticed, potential health risks, and any corrective actions that are being taken to remediate and prevent the occurrence from happening again. Management and consumer notification could be accomplished by speaking to them face-to-face or by telephone. Postal mail and electronic mail (e-mail) are more informal information transmission routes and are not recommended as the only communication method. Public notification may be appropriate before and after implementing some corrective actions. Several corrective actions are listed below:

- Water treatment process modification
- Distribution system flushing
- Increased chlorine residual concentration
- Elimination of a cross connection
- Transmission line replacement
- Transmission line interior coated with an Environmental Protection Agency-approved synthetic coating
- Installation of a point-of-use or point-of-entry device

As a final step in the complaint handling process, consumer complaint data should be converted to electronic form. Once completed, electronic data can then be manipulated and used to create charts, graphs and maps. While these maps are particularly useful to the installation management in determining how consumers view water quality on the installation, they also provide decision makers information about an ongoing crisis. For instance, should numerous complaints be filed these can be plotted on a map of the distribution system. From this map, emergency responders and installation managers can estimate the number of consumers affected and determine the location of the contaminated water and system valves.

RECOMMENDATIONS

- Military installations should re-prioritize tasks in order to expeditiously address consumer complaint system revisions and upgrades.

- All military installations should designate one organization (i.e., water system managers or the environmental office) as the single point-of-contact for all consumer complaint issues using Memorandums of Understanding or Memorandums of Agreement. Also, installations should conduct a consumer education program so that its populace knows where to call when they notice a water quality problem. Awareness can be accomplished through articles or advertisements in installation newspapers, in-processing information packages, and CCRs.

- Military installations within the continental United States should contact their State primacy agency responsible for drinking water regulations. Military installations should determine if there is a State-specific requirement for handling consumer complaints. Military installations that are outside the continental United States are not required to address consumer complaints; they should, however, develop and implement programs for the abovementioned health surveillance reasons.

- Installations that require additional assistance in dealing with consumer complaints or the complaint handling system should contact the USACHPPM, WSMP at DSN 584-3919, commercial (410) 436-3919, or by electronic mail at <Water.Supply@apg.amedd.army.mil>.

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