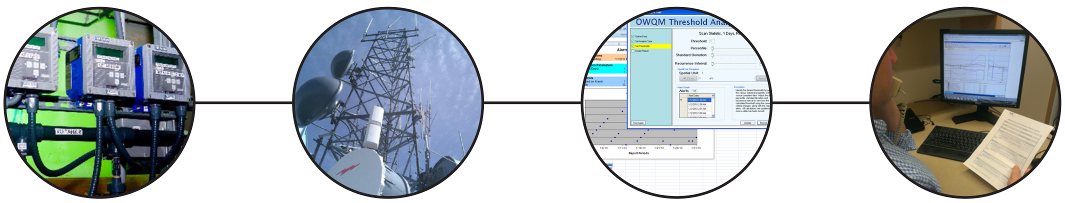
EPA
United States
Environmental Protection
Agency

Online Water Quality Monitoring Primer

For Water Quality Surveillance and Response Systems



Office of Water (MC 140) EPA 817-B-15-002A May 2015

Introduction

A Water Quality Surveillance and Response System (SRS) provides a systematic framework for enhancing distribution system monitoring activities to detect emerging water quality issues and respond before they become problems. An SRS consists of six components grouped into two operational phases, surveillance and response. The surveillance components are designed to provide timely detection of water quality incidents in drinking water distribution systems and include: Online Water Quality Monitoring, Enhanced Security Monitoring, Customer Complaint Surveillance and Public Health Surveillance. The response components include Consequence Management and Sampling & Analysis, which support timely response actions that minimize the consequences of a contamination incident. The *Water Quality Surveillance and Response System Primer* provides a brief overview of the entire system (USEPA, 2015).

This document provides an overview of Online Water Quality Monitoring (OWQM), a surveillance component of an SRS. It presents basic information about the goals and objectives of OWQM in the context of an SRS. This primer covers the following four topics:

- **Topic 1**: What is OWQM?
- **Topic 2**: What are the major design elements of OWQM?
- **Topic 3**: What are common design goals and performance objectives for OWQM?
- **Topic 4**: What are cost-effective approaches for OWQM?

Topic 1: What is OWQM?

OWQM utilizes real-time water quality data collected from monitoring stations deployed at strategic locations in a distribution system. The data generated at these stations is continuously analyzed to support system operation and detect water quality anomalies.

OWQM provides valuable insight into real-time conditions throughout a distribution system. This information allows utilities to detect incidents of unusual water quality which can allow for earlier, and thus more effective, corrective actions if necessary. It can also be used to derive day-to-day benefits, such as optimizing system operation, supporting regulatory compliance and enhancing asset management. Benefits derived from OWQM are further described under Topic 3 of this document.

Topic 2: What are the major design elements of OWQM?

The major design elements associated with OWQM are summarized in **Figure 1** and described under the remainder of this topic.

Data Generation
Monitoring stations continuously measure water quality parameters at strategically identified locations in a distribution system

Data Communication
Data is transmitted to a central location

Information Management & Analysis
Information is made available to utility staff, and data is analyzed to identify water quality anomalies

Alert Investigation
Utility staff are alerted to anomalies and initiate an investigation

Figure 1. OWQM Design Elements

Data Generation

The data generation design element determines the water quality data produced through OWQM. It is defined by the following three decisions:

- **What to monitor**: The parameters monitored in distribution systems determine both the information available to utility staff and the types of water quality incidents that can be detected by OWQM. Monitoring can include:
    - Conventional parameters such as, disinfectant residual, pH, turbidity, specific conductance, oxidation-reduction potential and temperature
    - Advanced parameters such as, TOC and UV-Vis spectral absorbance
    - Hydraulic parameters such as, pressure and flow

> **DID YOU KNOW?**
>
> Many drinking water utilities have existing capabilities and resources that can provide the foundation for OWQM.

- **How to monitor**: The sensor technologies used to monitor selected parameter(s), as well as the equipment required to install this technology at monitoring stations, can dramatically impact the capital costs, operating costs, data accuracy and required maintenance associated with OWQM.
- **Where to monitor**: Monitoring stations can be located anywhere in a distribution system, and may include utility-owned facilities (pump stations and storage tanks), city-owned facilities (fire and police stations), large water users such as bottling plants and hotels, and stand-alone installations.

Data Communication

The data communication design element involves the transmission of OWQM data to a central location for storage and access. Methods of communication for OWQM may include digital subscriber lines, cellular networks, radio and city-owned wireless networks. The type and quantity of data produced, existing communication capabilities and the locations from which data must be transmitted can impact selection of data communication solution(s).

Information Management and Analysis

Information Management: An information management system receives information, processes and stores it, and makes it available to users. Below are sample screen shots of user interfaces through which users can access, view and manipulate OWQM information. **Figure 2** shows a screen developed within a SCADA system to display recent values of all parameters measured at a given monitoring location. **Figure 3** shows a sophisticated, GIS-based interface in which the status of all monitoring stations can be viewed at a glance. In both cases, users can navigate within the interface to get more details about parameter values, alerts and station status.

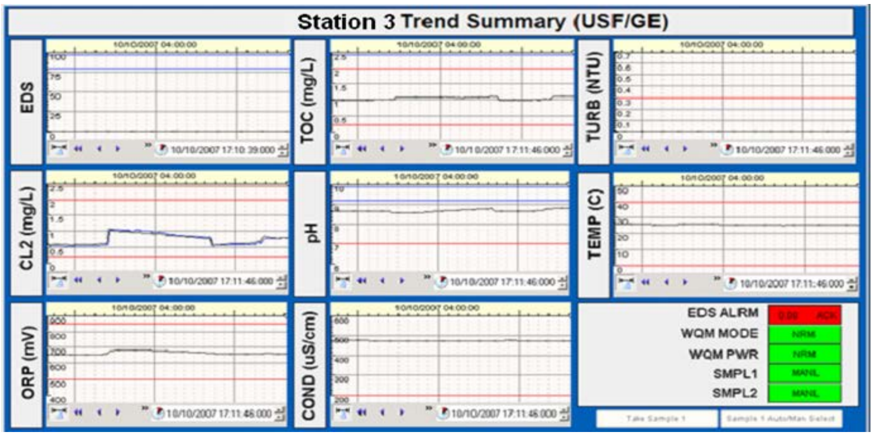


Figure 2. OWQM User Interface Using SCADA

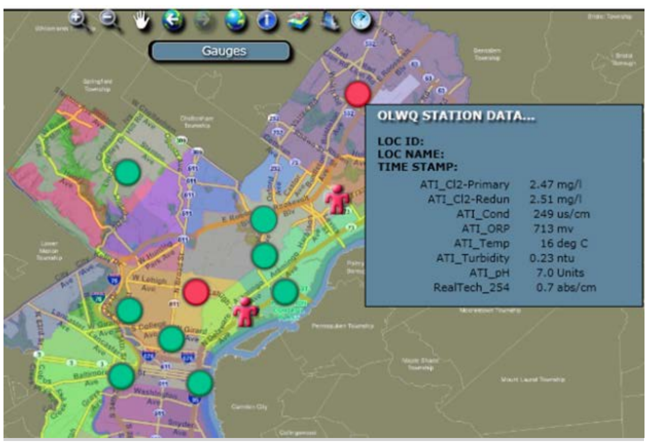


Figure 3. GIS-based User Interface

Data Analysis: OWQM data must be regularly reviewed to support system operations and detection of water quality anomalies. Data analysis methods vary in complexity, ranging from simple setpoint alerts to sophisticated computer algorithms. When a water quality anomaly is detected, an alert can be generated to notify utility staff.

Figure 4 shows an example of OWQM data that would likely trigger an alert. The vertical black lines identify a period of time in which both disinfectant residual and pH levels deviate from baseline water quality at a monitoring location.

DID YOU KNOW?

Regular, visual review of OWQM data by utility staff can provide awareness of real-time system conditions and detection of water quality anomalies.

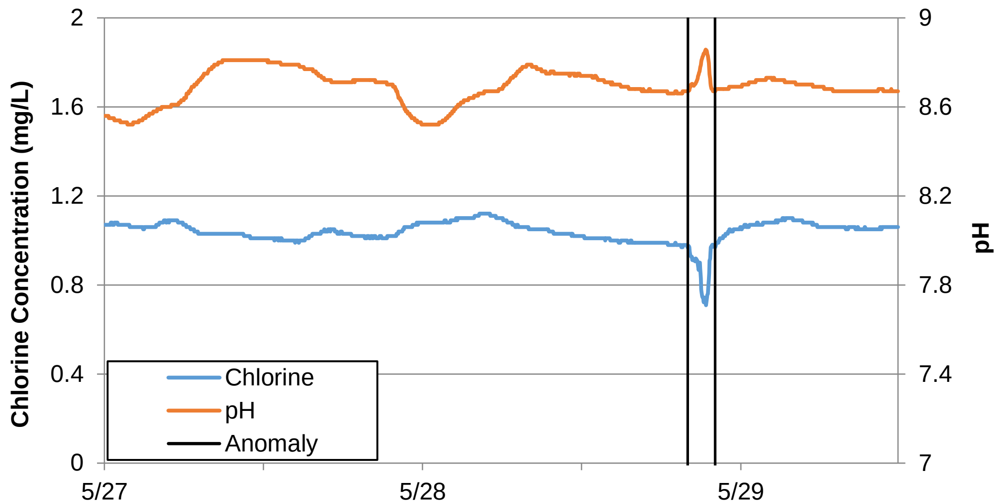


Figure 4. Example of a Water Quality Anomaly

Alert Investigation

When an alert is received, utility personnel follow defined alert investigation procedures to identify its cause. In many cases, a simple review of information is sufficient to determine that an alert does not indicate anomalous water quality, and is therefore invalid. Common causes of invalid alerts include sensor malfunction and data communication failure. If a cause can't be identified through data review, an on-site investigation can be conducted at the monitoring location that generated the alert to determine if accurate data is being generated and communicated. A sample may be collected at the site to further aid the investigation.

If it is determined that an alert was caused by a water quality incident, it may be necessary to take corrective actions to mitigate potential consequences. For example, if the alert was caused by low disinfectant residual data, steps may be taken to increase concentrations in the area. However, if a cause cannot be determined, the possibility of system contamination is further investigated using procedures in the utility's consequence management plan.

Topic 3: What are common design goals and performance objectives for OWQM?

The design goals and performance objectives established for OWQM by a utility provide the basis for the design of an effective component.

OWQM Design Goals

Design goals are the specific benefits that utilities expect to achieve by implementing OWQM. A fundamental design goal of an SRS is the ability to detect and respond to water quality incidents in a distribution system. In addition to this fundamental SRS design goal, other OWQM-specific design goals, such as optimizing water quality in the distribution system, can be realized. Examples of common OWQM design goals are listed in **Table 1**.

Table 1. Examples of Common OWQM Design Goals

Design Goal	Description
Detect water quality incidents	OWQM data can be used to detect unusual water quality conditions in distribution systems. This can include regular system occurrences such as nitrification, pressure transients, rusty or turbid water, treatment process failures, pipe breaks and excessive water age. OWQM also provides the ability to detect foreign substances in distribution systems resulting from leaky pipes, inadvertent cross-connections, backflow events, chemical overfeeds during treatment and intentional contamination.
Optimize system operation	Knowledge of real-time water quality and improved understanding of the impact of operational changes on water quality and hydraulic flow paths may allow staff to better manage application of treatment chemicals and may inform pump, valve and tank operation.
Support compliance with water quality goals and regulations	Information collected throughout a distribution system, particularly in areas of concern, can help identify when water quality goals aren't met and can provide time for corrective action in order to avoid potential compliance issues.
Enhance asset management	Regular data review can reveal changes in system conditions that can affect the performance and longevity of assets such as pipes, pumps, valves and storage tanks.

OWQM Performance Objectives

Performance objectives are measurable indicators of how well an SRS meets the design goals established by a utility. Throughout design, implementation and operation of an SRS or its components, utilities can use performance objectives to evaluate the added value of each capability, procedure or partnership. While specific performance objectives should be developed by each utility in the context of its unique design goals, general performance objectives for an SRS were defined in the *Water Quality Surveillance and Response System Primer* (USEPA, 2015) and are further described in the context of OWQM as follows.

- **Incident coverage**: Maximize the types of water quality incidents that can be detected. The types of water quality changes that can be detected by a specific OWQM component are determined by the parameters monitored, as an incident can only be detected if it causes a change in a monitored parameter.
- **Spatial coverage**: Maximize the portion of a distribution system that is monitored. For OWQM, this is determined by the number and locations of monitoring stations, as incidents of abnormal water quality can only be detected if affected water flows through a monitoring station.
- **Timeliness of detection**: Minimize the time required to detect a water quality anomaly. For OWQM, detection time includes the time for the unusual water to flow to a monitoring location, the time for an alert to be generated based on this data, and the time for utility staff to recognize the alert and complete alert investigation procedures.
- **Operational reliability**: Maximize the percentage of time that OWQM is fully operational. This requires proper maintenance of all equipment and information management systems, as well as consistent implementation of standard operating procedures by utility personnel.
- **Alert occurrence**: Minimize the number of invalid alerts, which are not caused by abnormal water quality, while maintaining the ability of the system to detect true water quality anomalies. Alerting is primarily impacted by the accuracy of OWQM data generated and the data analysis method(s) used.
- **Sustainability**: Realize benefits that justify the costs and level of effort required to implement and operate OWQM. Benefits are largely determined by the information produced by the system, which allows for day-to-day system monitoring and detection of water quality incidents. Costs

include the capital and ongoing costs and level of effort required to implement and operate the equipment and systems, as well as the effort required to investigate alerts generated.

Topic 4: What are cost-effective approaches for OWQM?

Utilities can take the following simple steps to develop the foundation for OWQM:

- Utilize distribution system water quality data already being collected (for example, disinfectant residual concentrations at utility-owned facilities).
- Build SCADA screens that display data plots or develop spreadsheets for data review.
- Establish procedures for regular, manual review of data (for example, reviewing data at the beginning of each shift) or create parameter setpoint alerts.
- Establish procedures for investigating water quality anomalies and train staff on their execution.

Next Steps

Visit the Water Quality Surveillance and Response Website at http://water.epa.gov/infrastructure/watersecurity/lawsregs/initiative.cfm for more information about SRS practices. The Website contains guidance and tools that will help a utility to enhance surveillance and response capabilities, as well as case studies that share utility experiences with SRS implementation and operation.

References

USEPA. (2015). *Water Quality Surveillance and Response System Primer*, 817-B-15-002.