
# Building Online Water Quality Monitoring Stations

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Gilbert Gedeon, P.E.

Continuing Education and Development, Inc.

P: (877) 322-5800
info@cedengineering.com

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Questions concerning this document should be addressed to WQ_SRS@epa.gov or the following contacts:

Matt Umberg
EPA Water Security Division
26 West Martin Luther King Drive
Mail Code 140
Cincinnati, OH 45268
(513) 569-7357
Umberg.Matt@epa.gov

or

Steve Allgeier
EPA Water Security Division
26 West Martin Luther King Drive
Mail Code 140
Cincinnati, OH 45268
(513) 569-7131
Allgeier.Steve@epa.gov

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- Steve Allgeier, EPA, Water Security Division
- Victoria Berry, CH2M
- Alan Lai, CH2M
- Sara Miller, CH2M
- Kenneth Thompson, CH2M
- Matt Umberg, EPA, Water Security Division

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- John Hall, EPA, Water Infrastructure Protection Division
- Johnny Partain, Dallas Water Utilities
- Ralph Rogers, Philadelphia Water Department
- David Travers, EPA, Water Security Division

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# Abbreviations

| | |
|---|---|
| AC | Alternating Current |
| ANSI | American National Standards Institute |
| DC | Direct Current |
| FRP | Fiberglass-Reinforced Plastic |
| NEMA | National Electrical Manufacturers Association |
| NSF | National Sanitation Foundation |
| OWQM | Online Water Quality Monitoring |
| PVC | Polyvinyl Chloride |
| SRS | Water Quality Surveillance and Response System |
| UL | Underwriters Laboratory |
| UPS | Uninterruptable Power Supply |

# Section 1: Introduction

A ***Water Quality Surveillance and Response System***[1] (SRS) is a framework designed to support monitoring and management of water quality in drinking water sources and distribution systems. An SRS consists of one or more components that enhance a drinking water utility's ability to quickly detect and respond to ***water quality incidents*** and provide information that can be used to improve distribution system operations. An overview of SRSs can be found in the *Water Quality Surveillance and Response System Primer*.

***Online Water Quality Monitoring*** (OWQM) is a component of an SRS that involves the use of online ***water quality instruments*** for ***real-time*** measurement of water quality at one or more locations in a source water or distribution system. Refer to the *Online Water Quality Monitoring Primer* for an overview of the OWQM component.

The information in this document can be used to design, fabricate, and install OWQM stations at a wide range of ***installation sites*** in a utility's watershed and distribution system. This document is primarily intended for use by water sector professionals during design and implementation of OWQM stations.

The remaining sections of this document cover the following topics:

- **Section 2** describes common station structures, how they have been used, and lessons learned from previous deployments.
- **Section 3** covers types of equipment that are required for basic stations, as well as accessories that can be added to enhance station functionality and reliability.
- **Section 4** covers station fabrication and installation considerations related to station fabricators, and approaches used to construct and deploy stations.
- **Resources** presents a comprehensive list of documents, tools, and other resources cited in this document that are useful for implementing activities described in this document.
- **Glossary** provides definitions of terms used in this document, which are indicated by bold, italic font at first use in the body of the document.

[1] Words in bold italic font are terms defined in the Glossary at the end of this document.

# Section 2: Station Structure

OWQM stations are typically constructed using one of five common types of structures: wall-mounted racks, free-standing racks, enclosed stations, compact stations, or floating platforms. The suitability of a structure type for a given monitoring application can be determined by evaluating the following station attributes:

- **Cost.** The capital cost to procure a station or purchase materials required for construction. Costs related to purchasing and maintaining water quality instruments and ancillary equipment, as well as the cost to maintain a station, are not covered in this document.
- **Fabrication.** The ease of procuring or constructing a station.
- **Flexibility.** A combination of both the suitability of a station for a range of site conditions and the potential for station relocation.
- **Footprint.** The space required for station installation, operation, and maintenance. Note that estimates provided in this document assume the most compact arrangement of available instruments and ancillary equipment that is possible.
- **Installation.** The ease of transporting a station, or station materials, to an installation site and preparing it for operation.
- **Protection.** The extent to which a station shelters instruments and ancillary equipment from installation site conditions (e.g., dust, extreme temperatures, precipitation). This includes only protection provided by a station itself, not that offered by an installation site (e.g., a building).
- **Security.** The protection provided by a station against tampering. This includes only security provided by a station itself, not that offered by an installation site (e.g., a building).

The following subsections describe the five common structure types, discuss station attributes, and summarize design considerations for station deployments. This information is based on experience with previous OWQM projects and vendor estimates.

## 2.1 Wall-Mounted Racks

Wall-mounted racks consist of water quality instruments and ancillary equipment that are secured to a mounting panel that is attached to a wall. These racks can be custom made or purchased as pre-plumbed, pre-wired units. Mounting panels are often made of polyvinyl chloride (PVC), aluminum, or coated-steel sheets to enhance the durability of a station. Pressure-treated plywood can be used for short-term installations, but exposure to caustic solutions (e.g., spilling or spraying of ***reagents***, buffers, or acid-based cleaning solutions during maintenance visits) can erode protective paint and cause deterioration of plywood, that could result in attraction of mold and other organisms.

Wall-mounted racks often require at least nine square feet of clear wall space. Racks are typically placed such that instruments and controls are about 5 to 6 feet above the ground, or near eye level, for ease of viewing and access. A minimum of 3 feet of space should be cleared in front of racks to avoid obstruction of equipment and maintain compliance with building codes. Supplies and equipment not mounted to a rack can be stored on shelves located on or near the panel. Refer to **Appendix A** for a schematic of a basic wall-mounted rack.

### 2.1.1 Application

Wall-mounted racks can be used for both source water and distribution system monitoring. They are most often installed because of the simplicity of their design. This allows these racks to be relatively inexpensive when compared to other types of structures, and it often enables utility personnel to complete station fabrication and installation. **Table 2-1** provides an overview of station attributes related to wall-mounted racks.

**Table 2-1. Wall-Mounted Rack Overview**

| Attributes | Rating<br>● = Positive<br>◒ = Neutral<br>○ = Negative | Details |
|---|---|---|
| Cost | ● | Cost of construction materials starts at about $100 for stations that use a PVC mounting panel and at about $500 for stations that use a coated-steel panel. |
| Fabrication | ● | Utility personnel can often complete fabrication. |
| Flexibility | ◒ | Requires an indoor site that has a suitable wall for mounting; these stations are often easy to relocate within the same site or move to a different site. |
| Footprint | ● | Requires at least 9 square feet of clear wall space for installation; a minimum of 3 feet of space should be cleared in front of stations. |
| Installation | ● | Utility personnel can often complete installation. |
| Protection | ○ | Does not offer protection against site conditions. |
| Security | ○ | Does not provide security against tampering. |

Wall-mounted racks are readily accessible and open to the surrounding environment, so they are most often installed inside utility-owned facilities. **Figure 2-1** shows a wall-mounted rack installation.

**Figure 2-1. Wall-Mounted Rack Installation**

### 2.1.2 Design Considerations

The following is a list of design considerations for wall-mounted racks:

- Select secure installation sites to prevent tampering. If such a site is available, instruct building occupants not to access stations for any reason. If a secure site is not available, it may be possible to install a protective cage like that shown in **Figure 2-2** to provide security for a station. Additionally, post signage to discourage occupants from accessing stations.
- Place racks in sites free of dirt, dust, debris, and extreme temperatures to ensure proper equipment operation.
- Confirm that walls can support the weight of stations prior to installation.
- Consider building shelves or installing a non-corrosive storage cabinet on or near stations to store reagents, manuals, spare parts, and equipment not secured to mounting panels.

**Figure 2-2. Wall-Mounted Rack with Protective Cage**

## 2.2 Free-Standing Racks

Free-standing racks consist of water quality instruments and ancillary equipment that are secured to a mounting panel that is attached to an open, structural frame. Structural frames are often made of coated steel (e.g., Unistrut®) framing members, and mounting panels can be made of aluminum, coated steel, or PVC.

Free-standing racks often require at least 8 square feet of floor space. These racks are typically about 6 feet in height to allow for relatively narrow designs. This also places instruments and controls near eye level and provides sufficient head clearance under a station's top crossbar for personnel to access equipment. These racks require up to 3 feet of clear space in front of and behind the stations to prevent obstruction of equipment. Wheels or casters can be added to the bottom of a rack to increase station mobility. Supplies and equipment not mounted to a rack can be stored on shelves located on or near the station. Refer to **Appendix B** for a schematic of a basic free-standing rack.

### 2.2.1 Application

Free-standing racks can be used for both source water and distribution system monitoring. They can be effective if a station must be mobile or if a site lacks sufficient wall space or stability to support a wall-mounted rack. These racks also allow equipment to be mounted and accessed from both sides of a mounting panel, which can reduce the station footprint. **Table 2-2** provides an overview of station attributes related to free-standing racks.

**Table 2-2. Free-Standing Rack Overview**

| Attributes | Rating<br>● = Positive<br>◒ = Neutral<br>○ = Negative | Details |
|---|---|---|
| Cost | ◒ | Cost of construction materials starts at about $2,000 for stations where instruments and ancillary equipment are mounted directly to framing members. |
| Fabrication | ◒ | Can be custom made or procured as a prefabricated unit from vendors or manufacturers. |
| Flexibility | ◒ | Requires an indoor site; these stations are often easy to relocate within the same installation site, but they can be difficult to move to a different site. |
| Footprint | ○ | Requires at least 8 square feet of floor space for installation; stations are often about 6 feet in height and require up to 3 feet of clear space in front of and behind racks. |
| Installation | ◒ | Utility personnel can often complete installation; stations can be difficult to hoist or lift during installation. |
| Protection | ○ | Does not offer protection against site conditions. |
| Security | ○ | Does not provide security against tampering. |

Free-standing racks are similar to wall-mounted racks in that they are readily accessible and open to the surrounding environment. Therefore, they are most often installed inside utility-owned facilities or in secure areas of other types of protected buildings (e.g., fire stations, police departments, hospitals). **Figure 2-3** shows a free-standing rack installation.

**Figure 2-3. Free-Standing Rack Installation**

### 2.2.2 Design Considerations

The following is a list of design considerations for free-standing racks:

- Select a secure installation site to prevent tampering. If such a site is available, instruct building occupants not to access stations for any reason. If a secure site is not available, it may be possible to install a protective cage. Additionally, post signage to discourage occupants from accessing stations.
- Place racks in sites free of dust, debris, and extreme temperatures to ensure proper equipment operation.
- Consider building shelves or installing a non-corrosive storage cabinet on or near stations to store reagents, manuals, spare parts, and equipment not secured to mounting panels.

## 2.3 Enclosed Stations

Enclosed stations consist of water quality instruments and ancillary equipment that are housed inside a custom-made, or prefabricated enclosure. Custom-made enclosures can be made of a wide range of materials and can often be built by utility personnel or contractors. Some prefabricated enclosures (e.g., cabinets, sheds) can be made of metal or plastic and can be purchased at local hardware stores. Others are fabricated according to National Electrical Manufacturers Association (NEMA) standards for enclosures that contain electrical equipment (https://www.nema.org/Standards/Pages/Enclosures-for-Electrical-Equipment.aspx). NEMA enclosures can be made of aluminum, epoxy-painted steel, fiberglass-reinforced plastic (FRP), or stainless steel, and can be procured from qualified panel fabrication shops.

Enclosed stations often require a footprint of at least 8 square feet. Stations are often about 6 feet in height to allow for relatively narrow designs. This also places instruments and controls near eye level to allow for easy access. These stations require enough clear space to allow their doors to open completely. Supplies and equipment can be stored inside the station, which provides protection against tampering, theft, and site conditions. Refer to **Appendix C** for a schematic of a basic enclosed station.

### 2.3.1 Application

Enclosed stations can be used for both source water and distribution system monitoring. They are most often installed because of the security and protection they provide for equipment. The ***benefits*** provided by this type of a station are dependent on the type of enclosure selected. Custom-made and prefabricated enclosures can be built or purchased to satisfy station requirements. NEMA enclosures are designed and fabricated to accommodate a range of monitoring applications and site conditions. NEMA 12 enclosures can be used for indoor installations to provide protection against dust, dirt, and non-corrosive liquids. NEMA 3R enclosures can be used for outdoor installations to vent moisture and provide protection against rain intrusion and ice formation. NEMA 4X enclosures, which are often more expensive than NEMA 3R and NEMA 12 enclosures, can be used for indoor and outdoor locations to provide protection against pressurized sprays and corrosive environments. Note that NEMA 4X enclosures do not include vents, so heat and condensation buildup can be a concern. More information on these types of NEMA enclosures can be found at https://www.nemaenclosures.com/enclosure-ratings/nema-rated-enclosures.html. **Table 2-3** provides an overview of station attributes related to enclosed stations.

**Table 2-3. Enclosed Station Overview**

| Attributes | Rating<br>● = Positive<br>◒= Neutral<br>○ = Negative | Details |
|---|---|---|
| Cost | ◒ | Cost of materials to construct custom-made enclosures can vary significantly; prefabricated enclosures start at about $250, and NEMA enclosures start at about $5,000. |
| Fabrication | ◒ | Generally takes longer to fabricate due to custom designs;<br>NEMA enclosures must be procured from qualified panel fabrication shops. |
| Flexibility | ◒ | Suitable for indoor and outdoor sites, but stations are often difficult to relocate within a site or move to a different site. |
| Footprint | ○ | Requires at least 8 square feet of floor space for installation; stations are often about 6 feet in height and require enough clear space to allow their doors to open completely. |
| Installation | ○ | Can be difficult to hoist or lift during installation; establishing connections through an enclosure to distribution system water, drain, power, and communications can add to the complexity of the installation. |
| Protection | ● | Offers significant protection against site conditions. |
| Security | ● | Provides an increased level of security; typically lockable to prevent tampering. |

Enclosed stations both protect and conceal instruments and equipment, so they are most often installed outdoors (e.g., in parks, public areas, watersheds) or inside unsecured facilities (e.g., city-owned facilities). **Figure 2-4** shows enclosed station installations that use prefabricated and NEMA enclosures.

**Figure 2-4. Enclosed Station Installations (Prefabricated and NEMA Enclosures)**

## 2.3.2 Design Considerations

The following is a list of design considerations for enclosed stations:

- For sites that lack a smooth, flat section of pavement to support a station, consider constructing a dedicated concrete pad to serve as a base.
- Install door locks to prevent unauthorized access.
- Include passive air vents to the exterior of enclosures to remove heat and moisture from stations.

- Depending on a site's climate and the temperature rating of a station's equipment, consider installing a small heater, air conditioning unit, or exhaust fan to regulate the temperature inside the enclosure. Additionally, placing a station under a shade structure can limit temperature increases in warm climates.
- Attach heat trace cable to sample lines to prevent sample water from freezing.
- For sites that lack surrounding infrastructure, consider using wireless communications and solar power with batteries.

## 2.4 Compact Stations

Compact stations are smaller versions of enclosed stations. They are often designed around a limited number of reagentless water quality instruments due to their relatively small footprint, although reagent-based instruments can be used in some cases. These stations are typically built using NEMA 4X enclosures. Enclosures can be made of aluminum, epoxy-painted steel, FRP, or stainless steel, and can be procured from qualified panel fabrication shops.

Compact stations often require a footprint of at least 1.5 square feet. These stations are typically a maximum of 3 feet in height and require enough clear space to allow their doors to open completely. Supplies and equipment are often stored offsite due to the limited space inside these stations. Refer to **Appendix D** for a schematic of a basic compact station.

### 2.4.1 Application

Compact stations can be used for both source water and distribution system monitoring. They are most often installed because of their small footprint. Similar to enclosed stations, the benefits provided by this type of station are dependent on the type of enclosure selected. Refer to Section 2.3 for information on the benefits provided by various types of NEMA enclosures. **Table 2-4** provides an overview of station attributes related to compact stations.

**Table 2-4. Compact Station Overview**

| Attributes | Rating<br>● = Positive<br>◒ = Neutral<br>○ = Negative | Details |
|---|---|---|
| Cost | ◒ | Cost of NEMA enclosures starts at about $1,500. |
| Fabrication | ○ | Generally takes longer to fabricate due to custom, tight designs; NEMA enclosures must be procured from a qualified panel fabrication shop. |
| Flexibility | ● | Suitable for indoor and outdoor sites; these stations are often easier to relocate than enclosed stations. |
| Footprint | ● | Requires at least 1.5 square feet of floor space for installation; stations are a maximum of 3 feet in height and require enough clear space to allow their doors to open completely. |
| Installation | ◒ | Connections through an enclosure to distribution system water, drain, power, and communications can add to the complexity of installation. |
| Protection | ● | Offers significant protection against site conditions. |
| Security | ● | Provides an increased level of security; typically lockable to prevent tampering. |

Compact stations have a small footprint and can both protect and conceal equipment, so they are most often installed outdoors at sites where deployment of larger enclosed enclosures is not feasible (e.g., in public rights-of-way, parking lots, parks) or inside buildings where space is limited. **Figure 2-5** shows an example of a compact station that was designed and fabricated by the Philadelphia Water Department.

**PHILADELPHIA WATER DEPARTMENT'S COMPACT STATIONS**


**Figure 2-5. Philadelphia Water Department Compact Station**

The Philadelphia Water Department has designed and fabricated "rapid deployment modules," which are examples of compact stations. These stations, which are about the size of a briefcase, can monitor chlorine residual, pH, conductivity, turbidity, and temperature.

These stations have been used for short-term, distribution system monitoring applications, such as monitoring during high-profile events, during changes in distribution system operations, and to support investigations into customer complaints related to water quality.

### 2.4.2 Design Considerations

Design considerations for compact station deployment are largely the same as those listed for enclosed stations in Section 2.3, with the following additions:

- Consider both the size and performance of instruments to add to these stations, as space is very limited.
- Design stations such that personnel can easily access instruments despite space limitations; add removable panels or a system that allows equipment to slide on rails to allow for easier access.
- Note that inclusion of station accessories, which are covered in Section 3.3, is often not feasible for compact designs due to space limitations.

## 2.5 Floating Platforms

Floating platforms consist of one or more NEMA 4X enclosures, containing water quality instruments and ancillary equipment, which are mounted to a flotation system (e.g., a navigation buoy, custom-made pontoon system). These stations can be custom made or purchased as complete units. A platform's flotation element is often made of synthetic foam; structural members are often made of aluminum or stainless steel. Reagentless instruments must be used with these stations due to the lack of infrastructure available to discharge waste streams that contain reagents. This type of station should include an anchor to keep it in a fixed location. These stations should also have a warning light to prevent collisions with recreational watercraft and allow utility personnel to locate the stations at night, if needed.

Floating platforms often require a footprint of at least 25 square feet and are at least 3 feet in height. Supplies and equipment are typically stored offsite due to the limited space available on the stations. Refer to **Appendix E** for a schematic of a basic floating platform.

### 2.5.1 Application

Floating platforms are used for source water monitoring only. They are most often deployed when installation of other types of structures on the bank of a waterbody is either infeasible or incapable of providing a water sample that is representative of the waterbody. Deployment of these stations may require the use of boats and, for large stations, cranes. **Table 2-5** provides an overview of station attributes related to floating platforms.

**Table 2-5. Floating Platform Overview**

| Attributes | Rating<br>● = Positive<br>◒ = Neutral<br>○ = Negative | Details |
|---|---|---|
| Cost | ○ | Cost of basic navigation buoy system starts at about $5,000. |
| Fabrication | ○ | Floating platforms generally take longer to fabricate due to custom designs and multiple station elements. |
| Flexibility | ● | Can be easy to relocate within the same waterbody, but they can be difficult to move to other waterbodies. |
| Footprint | N/A* | Requires at least 25 square feet of space for installation; stations are at least 3 feet in height. |
| Installation | ◒ | Deployment may require the use of boats and cranes. |
| Protection | ● | NEMA enclosures used on a platform offer significant protection for electronics and communications equipment against site conditions. |
| Security | ● | Stations are often accessible by boat only; NEMA enclosures provide an increased level of security for electronics and communications equipment. |

*Rating is not applicable because floating platforms are deployed on large waterbodies.

Floating platforms can be placed anywhere on the surface of a waterbody. Identifying potential monitoring sites requires an understanding of navigation routes and public recreational areas to minimize the likelihood of collisions with recreational watercraft and tampering. **Figure 2-6** shows a floating platform installation.

**Figure 2-5. Floating Platform Installation**

### 2.5.2 Design Considerations

The following is a list of design considerations for floating platforms:

- When designing stations, consider the waterbody to be monitored and site conditions (e.g., wave height).
- Prioritize instrument accessibility in station designs, as utility personnel typically access stations from a boat.
- Select instruments that can operate when immersed directly into a waterbody to avoid the need for pumps to collect sample water.
- Due to the lack of surrounding infrastructure, consider using wireless communications and solar power with batteries.

# Section 3: Station Equipment

The types of equipment that are incorporated into a station impact its functionality and reliability. Equipment should be appropriate for its intended monitoring application and able to operate properly in its intended monitoring environment.

This section covers basic types of equipment that are necessary for all stations as well as accessories that can be added. The section is divided into subsections that cover the following topics:

- Basic equipment
- Station accessories

## 3.1 Basic Equipment

Every station must be furnished with a basic set of equipment to carry out the primary OWQM functions of generating water quality data and transmitting it to a utility's ***control center***.

The types of basic equipment discussed in this section include these:

- Control panels
- Uninterruptible power supplies
- Water supply manifolds
- Water quality instruments, computing elements, and flow-cells
- Drain assemblies

Refer to Appendices A through E for schematics that depict how basic equipment can be incorporated into each of the station structures discussed in Section 2.

Note that this document does not cover equipment that is external to a station (e.g., power sources, distribution system water sources, waste drains). This equipment must be present at an installation site prior to station deployment.

### 3.1.1 Control Panels

A control panel distributes power throughout a station and facilitates communication within a station and between it and a control center. A control panel is often housed inside a dedicated NEMA 4X enclosure and contains circuit breakers (or fuses), a receptacle, a surge suppressor, and a communications system. Most stations accept power in 120 volts AC, although 24 volts DC is also possible (e.g., for solar-powered stations). **Figure 3-1** shows a typical power distribution configuration for a station. Control panels typically require Underwriters Laboratory (UL) 508 certification (most qualified panel fabrication shops are UL-certified). UL 508 requirements include industry-standard practices and methods for safe electrical construction of an enclosure with energized equipment.

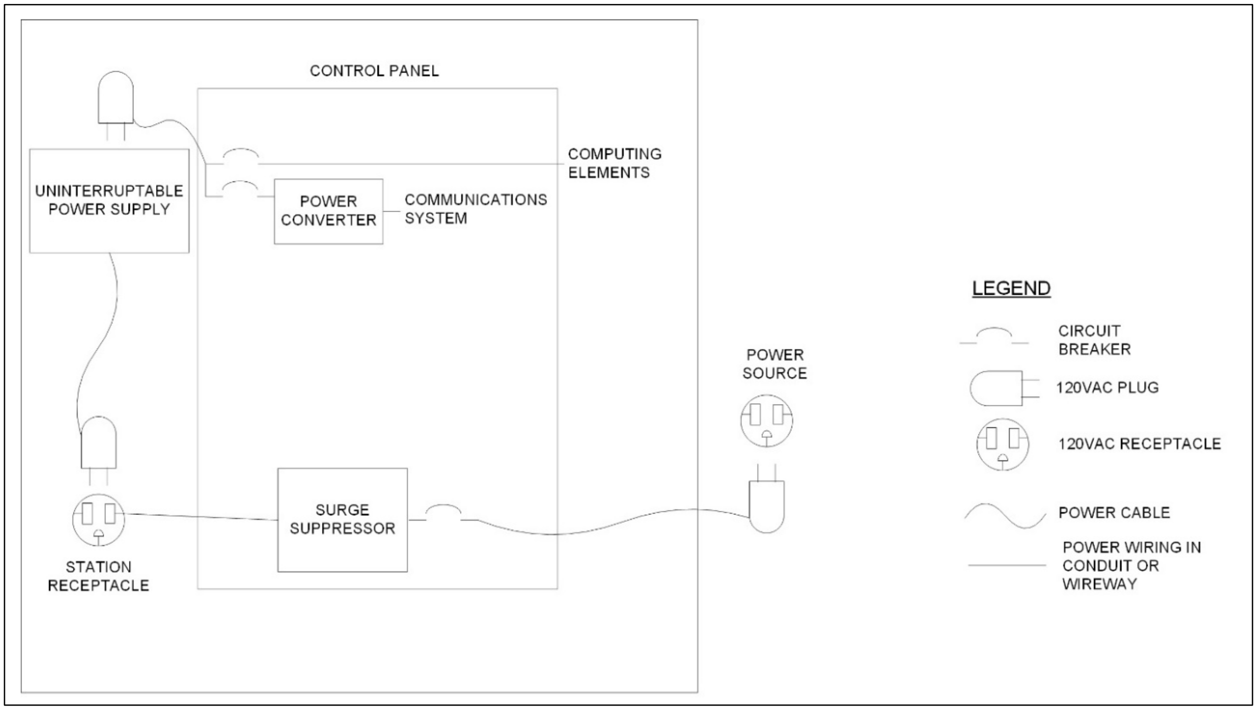



**Figure 3-1. Station Power Distribution Configuration**

Circuit breakers or fuses provide overcurrent protection for a station's energized equipment. Each piece of equipment should be hard-wired into one of these devices to prevent the entire station from losing power if a single piece of equipment experiences an electrical issue. For stations located at non-utility facilities, it can be helpful to install emergency power disconnects at power sources to allow utility personnel to cut power to a circuit without having to contact the facility owner.

A receptacle that has a built-in ground fault circuit interrupter minimizes the risk of electrical shock because of inadvertent water spills at a station.

A surge suppressor protects energized equipment from power spikes, or transients, that come from external sources. In most cases, a single surge suppressor, installed immediately downstream of a control panel's power supply, can provide protection for an entire station.

A communications system facilitates the transfer of water quality data from a station to a control center. Both wired and wireless communications systems can be effective for OWQM stations. Note that, if a wireless system is installed inside an enclosed or compact station, the enclosure must be made of a non-metallic material (e.g., FRP, polyester, polycarbonate) or the system's antenna must either protrude through the enclosure or be remotely mounted to transmit a signal. If an antenna is exposed to the outside environment, the antenna cable may need to be connected to a dedicated surge suppressor inside the control panel box prior to connecting to a station's communications system (e.g., cellular modem). Also, if the wireless signal is poor at a site (e.g., in a basement), a communications system may have to be installed in a separate location (e.g., a top floor) and connected to the station. For more information on deploying communications systems, refer to *Guidance for Designing Communications Systems for Water Quality Surveillance and Response Systems*.

### 3.1.2 Uninterruptable Power Supplies

An uninterruptable power supply (UPS) can provide a station with a temporary power source if the primary source fails. UPSs used for OWQM often provide 1,000 to 1,500 volt-amperes of power and typically provide 2 to 8 hours of run time in the event of a power failure (the exact time depends on the power consumption of UPS-connected devices). To maximize run time during a power outage, UPSs should only be connected to critical devices, such as water quality instruments and communications equipment. UPSs should be compatible with the temperature, humidity, and vibration typically present at a site, as unfavorable conditions can reduce the useful life of a UPS battery. Note that UPSs often use gel, cell-type batteries, which can expel hydrogen and oxygen gas through battery valves when overcharged. Therefore, air vents should be installed for enclosed or compact stations to allow for sufficient diffusion and ventilation if this type of battery is used.

### 3.1.3 Water Supply Manifolds

A water supply manifold is an apparatus that distributes sample water throughout a station. Manifolds are typically made of copper piping and brass fittings. All connections must be sealed with Teflon tape, as opposed to Teflon pipe dope that can seep into the water and potentially interfere with water quality instrument operation and measurement. Manifolds often include the following features:

- **Supply bulkhead.** A fitting that allows a distribution system water source (e.g., a hose or tubing) to connect to a manifold.
- **Backflow prevention device.** A device that prevents sample water from returning to the distribution system once it enters a manifold. These devices should be included in every station.
- **Strainer/filter.** "Y" strainers are common devices that remove unwanted debris (e.g., displaced sediment) from sample water prior to contact with water quality ***sensors***. These strainers are typically 100 microns in size and do not act as pre-filters that could impact water quality parameters, such as ***turbidity***. In cases where sensitive instruments require additional protection, 50-micron strainers have been used without impacting measured values. In-line traps are devices that can control microbubble formation, as needed.
- **Flow gauge/sensor.** Devices that measure the flow of sample water that enters a manifold. Gauges typically indicate current values on the devices themselves, while sensors can often display current values at the station and transmit data to a control center.
- **Pressure regulator.** A device that reduces the pressure of sample water in a manifold from distribution system levels to levels that meet instrument specifications.
- **Isolation valve(s).** A device that enables the flow of sample water to water quality sensors.
- **Sampling port(s).** A device that allows for the collection of water samples for field or laboratory analysis.
- **Pressure gauge/sensor.** Devices that measure the water pressure inside a manifold. Gauges typically indicate current values on the devices themselves, while sensors can often display current values at the station and transmit data to a control center. These devices can be placed upstream of a pressure regulator to monitor distribution system pressure and potentially identify water quality incident (e.g., main breaks). They can also be placed downstream of a regulator to ensure that pressure levels within a station are consistent with operating ranges listed in instrument specifications.
- **Drain valve.** A mechanism that allows for rapid purging of unwanted debris. This is particularly useful during initial start-up and after maintenance on upstream water supply lines.

**COMPLIANCE WITH NSF/ANSI STANDARDS**

Station materials that contact sample water upstream of a backflow prevention device should comply with *NSF/ANSI 61: Drinking Water System Components*. In cases where sample water is pumped back into a distribution system, all station materials that contact sample water should comply with this standard.

Refer to Appendices A through D for schematic details that show basic manifold configurations. Note that manifolds are not needed for floating platform stations if water quality sensors are immersed directly into a waterbody.

### 3.1.4 Water Quality Instruments, Computing Elements, and Flow-Cells

Water quality instruments measure OWQM parameters in the sample water that flows through a station. The selection of parameters to monitor and instruments to install significantly impacts the benefits that can be realized from OWQM. For information on OWQM parameters and the benefits they can provide as part of source water monitoring and distribution system monitoring systems, refer to *Online Source Water Quality Monitoring for Water Quality Surveillance and Response Systems* and *Online Distribution System Water Quality Monitoring for Water Quality Surveillance and Response Systems*, respectively. For information on types of technologies that are available to monitor parameters and additional considerations for selecting instruments, refer to *Guidance for Selecting Online Water Quality Monitoring Instruments for Source Water and Distribution System Monitoring*. For a list of available instruments that includes general information about each instrument, refer to *List of Available Online Water Quality Monitoring Instruments*.

Each station must include one or more local computing elements, which is typically a proprietary instrument controller (e.g., Hach SC1000, s::can con::cube, YSI IG SensorNet). However, in some cases an instrument controller is an industrial computer that can provide more complex and flexible processing capabilities.

Some instruments require the use of a flow-cell to control the pressure or flow rate of sample water that contacts water quality sensors. In this case, sensors can be inserted directly into a flow-cell. Flow-cells can enhance instrument performance and improve the quality of the data that is generated.

### 3.1.5 Drain Assemblies

A drain assembly collects and directs a station's waste streams, which consist of sample water that has been analyzed by water quality instruments, to a suitable outlet for disposal. A drain assembly often consists of a plastic funnel connected to PVC piping that extends to an outlet. The funnel is a critical feature of a drain assembly because it creates an air gap, or unobstructed vertical space between waste stream tubing and an assembly, which provides backflow protection for a station. The height of an air gap should be at least twice the diameter of waste stream tubing.

For most indoor installations, assemblies can direct waste streams to a floor drain for disposal into a public sewer system. For most outdoor, land-based installations, assemblies can direct waste streams to a sewer pipeline; if a sewer pipeline is not available, waste streams can be directed to a ***dry pit***. If a dry pit is used, hazardous solutions (e.g., calibration standards, buffers, reagents) should be collected in a large container, such as a carboy, and transported to a sanitary drain for disposal. For floating platforms that use reagentless instruments, assemblies can return waste streams to the waterbody. In all cases, state and local discharge requirements should be considered to ensure proper disposal of waste streams.

## 3.2 Station Accessories

Station accessories can be added to enhance the reliability and functionality of a station. These accessories often interface with a station's control panel. The feasibility of including accessories in a design typically depends on a utility's capital budget for procurement, annual operating budget, availability of personnel for maintenance, desired functionality of a station, and installation site conditions.

The types of station accessories discussed in this section include these:

- Lighting fixtures
- Autosamplers
- Calibration switches
- Door switches
- Leak detection sensors
- Internet protocol cameras
- Panel interface connectors
- Ethernet switches
- Personal safety materials

### 3.2.1 Lighting Fixtures

Lighting fixtures can supplement the external light typically present at a site. These fixtures allow utility personnel to safely access stations at night and at sites that lack sufficient lighting. Fixtures are often mounted to the top of wall-mounted and free-standing racks, or to the ceiling of enclosed and compact stations. They are typically not included on floating platforms. LED lights are particularly effective for remote installations as they consume a relatively low amount of power and require less frequent bulb replacement.

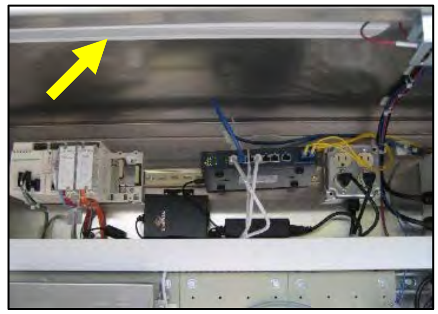


**Figure 3-2. Lighting Fixture**

### 3.2.2 Autosamplers

If a station contains a computing element that allows for remote control of the station, autosamplers allow utility personnel to trigger the collection of water samples at a station immediately after a water quality ***anomaly*** is detected. This enables personnel to retrieve and analyze samples that are present at the time of an ***alert***, as opposed to samples that are manually collected after that water has passed through the station.

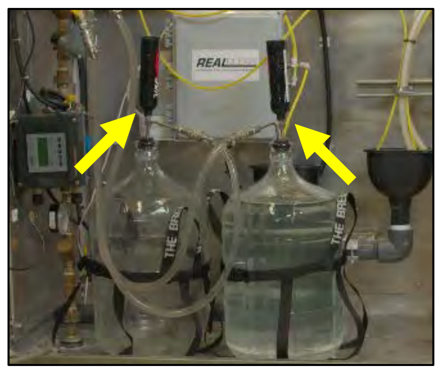


**Figure 3-3. Autosamplers**

Autosampler bottles often sit on the ground beneath wall-mounted and free-standing racks, or on the floors of enclosed and compact stations. They can be installed on floating platforms if sufficient space is available and a pump is provided to collect sample water from a waterbody. Autosamplers often collect samples in 5-gallon bottles made of plastic or glass (glass is needed for samples that are analyzed for organic compounds). The tap for the tubing leading to the sample bottles is typically placed downstream of the in-line pressure reducer on a station's water supply manifold. A solenoid valve should be placed at the sample port and connected to the station's computing element to allow for remote actuation of the sample tap.

The sample bottle is usually capped to prevent contamination prior to sample collection. The cap should be fitted with an inlet for sample collection and a check valve to allow air to escape as the sample bottle fills. The check valve can include a filter to remove particulates and organics from air purged from the bottle during sample collection. Personnel should program the station's computing element so the sample tap stays open long enough to fill the sample bottle without overfilling it. Two sample bottles with independent sampling solenoids can be installed to allow for collection of multiple samples. In most cases, preservatives and quenching agents should not be added to sample bottles, as they can be added to bottles designated for specific analyses during sub-sampling.

### 3.2.3 Calibration Switches

Calibration switches can notify utility personnel when calibration or maintenance activities are taking place at a station. Data generated while these switches are activated can be flagged to indicate that any water quality anomalies detected during this time are likely the result of work being performed at the station. These switches are often installed on the face of a station's control panel for all types of stations. An indicator light can be added to both signal that a switch has been activated and remind technicians to return the switch to its normal setting prior to the end of a visit. If a technician fails to return a switch to its normal setting, utility personnel can do so remotely from a control center if the station's computing element allows for remote control of the station.

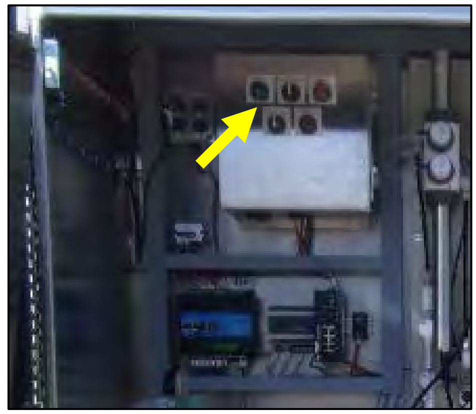


**Figure 3-4. Calibration Switches**

### 3.2.4 Door Alarm Switches

Door alarm switches can generate alerts to notify utility personnel when a station door has been opened or when a door has been opened for longer than expected. In the absence of calibration switches, door alarm switches can indicate when calibration or maintenance activities are taking place at a station. Personnel can also use these switches to detect unauthorized accessing of a station. These switches are often installed inside enclosed and compact stations such that they are activated and deactivated when station doors open and close, respectively. They are not typically used for wall-mounted racks, free-standing racks, or floating platforms.

**Figure 3-5. Door Alarm Switch**

### 3.2.5 Leak Detection Sensors

Sensor environments should be kept consistently dry to avoid nuisance alerts. Leak detection sensors can be used to generate alerts to notify utility personnel when plumbing leaks and sample bottle overflows occur at a station. These sensors can be mounted to the bottom of wall-mounted and free-standing racks, or placed on the floor beneath these racks if they have an open bottom with spill containment. They can also be placed on the floor of enclosed stations and compact stations, or inside floating platform control panels. If a leak is detected, personnel can remotely shut off a station's water supply if the station's computing element allows for remote control of the station.

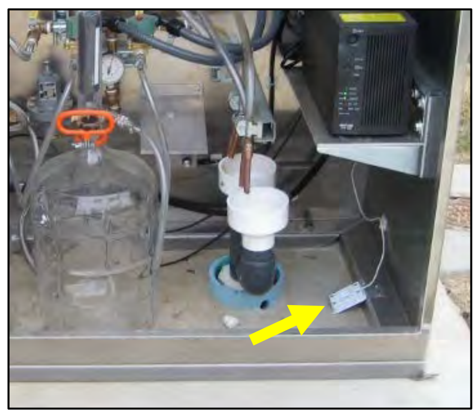


**Figure 3-6. Leak Detection Sensor**

### 3.2.6 Internet-Protocol Cameras

Internet-protocol cameras equipped with microphones allow utility personnel to view a station to examine for leaks, hear audible alarms, and identify unauthorized access. These cameras typically offer the ability to pan, tilt, and zoom, and select alternate viewing modes (e.g., low-light, infrared). Cameras can be installed anywhere at a site that has a clear view of wall-mounted and free-standing racks. They can be installed inside enclosed and compact stations in a top corner that has a clear view of the station. Waterproof and underwater cameras can be installed on floating platforms above or below the water surface.

**Figure 3-7. Internet-Protocol Camera**

### 3.2.7 Panel Interface Connectors

Panel interface connectors for Ethernet or 120VAC connections installed on the outside of control panel boxes can allow utility personnel to plug equipment, such as a notebook PC, into the panels without having to open the box. This capability is particularly useful for utilities that do not allow personnel to open energized panels without an electrical safety permit. These connectors are typically installed on the face of the control panel for wall-mounted racks, free-standing racks, enclosed stations, and compact stations. They are not typically included on floating platforms. Although these connectors have a cover that is usually closed, they should be placed above and away from all water tubes to protect against spraying from system leaks. Installing a lockable cover on panel interface connectors can provide additional physical security.

**Figure 3-8. Panel Interface Connector**

### 3.2.8 Ethernet Switches

An Ethernet switch is required when the number of computing elements used to transmit data to a control center is larger than the number of Ethernet ports available on the communications device (e.g., cellular modem) present at a station. Ethernet switches are most often installed inside a station's control panel box for all types of stations.

**Figure 3-9. Ethernet Switch**

### 3.2.9 Personal Safety Materials

Storing personal safety materials at stations can help to ensure the safety of personnel who conduct maintenance activities for station equipment. Examples of such materials may include safety glasses, latex gloves, disposable ear plugs, hard hats, safety boots, Material Safety Data Sheets (for any reagents that are used at the stations), first aid kits, eye wash supplies, and a listing of the nearest medical centers in case of an emergency.

**Figure 3-10. Personal Safety Materials**

**REDUNDANT INSTRUMENTS**

Installation of multiple water quality instruments that measure the same parameter at a station ensures constant generation of water quality data in the event of a ***sensor malfunction***. Also, data precision can be assessed by comparing data from the two instruments.

# Section 4: Fabrication and Installation Considerations

Several considerations can impact the selection of qualified personnel and approaches used for station fabrication and installation. The resulting decisions made by utilities can significantly impact the efficiency of OWQM deployment and performance of stations.

This section covers common station fabrication and installation considerations. The section is divided into subsections that cover the following topics:

- Utility personnel vs. external contractors
- On-site construction vs. prefabricated stations
- Design-build vs. design-bid-build

## 4.1 Utility Personnel vs. External Contractors

Following the design of stations, utilities should assess the availability and capability of internal personnel to complete fabrication and installation activities.

Fabrication activities typically include these:

- Planning and design of stations
- Fabrication of stations
  - Welding and metal fabrication
  - Water quality instrument and control panel wiring
  - Plumbing within the stations

Installation activities typically include these:

- Site modification (e.g., demolition, drain waste vent piping, electrical service connections, construction of a concrete base)
- Pipe work (e.g., making municipal water plumbing connections, pipe penetrations)
- Coordination of equipment delivery to a site
- Systems integration support
- Organization of post-installation inspections, start-up, training, and acceptance

If utility personnel have sufficient availability and are both capable and certified to do so, it is often preferred that they complete the above activities. However, if personnel are unable to complete these activities, or if a utility would like to leverage the experience of OWQM specialists, external contractors can be hired to provide assistance. Note that if contractors are involved with station installation at a privately-owned facility, negotiations may be required to address issues such as legal liability and risk.

It is recommended that utilities engage instrument vendors following station installation to provide on-site training for operations and maintenance.

## 4.2 On-Site Construction vs. Prefabricated Stations

Stations can either be constructed at installation sites or delivered to sites as prefabricated units. The ideal approach for an installation is often determined by the complexity of a station’s design and site conditions.

On-site construction of a station involves the delivery of water quality instruments, ancillary equipment, and construction materials to a site, and then personnel assembling the station on location. This approach is most often used when station designs are relatively simple and sites provide sufficient space to complete assembly. It can also be effective when delivery of an assembled station to a site is infeasible (e.g., if site access points are narrow).

Prefabricated stations are constructed offsite and delivered to sites as complete units. These stations are most often used when designs are relatively complex or when sites lack sufficient space for on-site assembly. They can also be effective when fully assembled stations can be delivered to a site without difficulty or when security may be an issue at a site. Because these stations are often constructed, inspected, and tested by the same individuals under controlled conditions, there is a greater likelihood they are constructed in a consistent, effective manner.

In cases where a prefabricated station is desired but space is limited at installation site access points (e.g., a basement that has a narrow staircase for access), a combination of the above approaches can be used. Separate modules can be fabricated offsite, delivered to a site, and assembled on location. This approach provides many of the benefits of prefabricated stations, but the separate modules are often easier to transport to a site.

## 4.3 Design-Build vs. Design-Bid-Build

The most common approaches used to design and fabricate stations are the design-build and design-bid-build project delivery methods. The suitability of each method for a given project is often determined by utility procurement policies, project budgets and schedules, and the desire of utility personnel to participate in the design and fabrication processes.

The design-build method consists of utilities developing a set of station qualifications for a system integrator and then procuring services from one or more entities for design, fabrication, startup, and transfer to the utility. This method is often effective when a utility has a compressed project schedule and would prefer that a single contractor be responsible for design, fabrication, and installation. **Table 4-1** summarizes the advantages and disadvantages of this method.

**Table 4-1. Design-Build Summary**

| Advantages | Disadvantages |
|---|---|
| • Construction typically starts before the design is completed, which can shorten the project schedule.<br>• Construction costs may be fixed and known during the design process, which places an emphasis on controlling project costs (progressive design-build processes will develop costs with a contractor by the 30% design).<br>• Utilities do not need detailed design expertise, although technical knowledge is required to develop specifications.<br>• Utilities and design-build entities share design and construction risk. | • Comprehensive and carefully prepared plans and specifications may be required during the 30% design phase.<br>• Utilities may incur additional costs if changes are made to plans and specifications after the 30% design is locked in. |

The design-bid-build method consists of utilities procuring design entities to develop detailed station specifications, and then using those specifications to procure a contractor to fabricate stations. This method is often effective when a utility has an extended project schedule or when utility or state policies do not allow for alternative delivery approaches. **Table 4-2** summarizes the advantages and disadvantages of this method.

**Table 4-2. Design-Bid-Build Summary**

| Advantages | Disadvantages |
|---|---|
| • Utilities can work with design entities to ensure that desired requirements are included in specifications prior to construction beginning.<br>• The process of procuring construction contractors is typically competitive, which can result in lower construction costs.<br>• Utilities have a better understanding of the expected cost of a project. | • Design and construction are performed in series, which often results in longer project schedules.<br>• Construction costs are not locked in until a contract is awarded (but are typically closely estimated costs).<br>• Utilities must execute separate procurements for design entities and construction contractors.<br>• Utilities or design consultants are financially liable for design errors that require modifications during construction.<br>• It can be difficult to resolve construction disputes due to shared responsibility for delivery. |

# Resources

**Guidance for Designing Communications Systems for Water Quality Surveillance and Response Systems (EPA, 2016)**

This document provides guidance and information to help utilities select an appropriate communications system to support operation of an SRS. It provides rigorous criteria for evaluation communications system options, evaluates common technologies with respect to these criteria, describes the process for establishing requirements for a communications system, and provides guidance on selecting and implementing a system. (EPA 817-B-16-002, September 2016.)
https://www.epa.gov/sites/production/files/2017-04/documents/srs_communications_guidance_081016.pdf

**Guidance for Selecting Online Water Quality Monitoring Instruments for Source Water and Distribution System Monitoring (EPA, in press)**

This document provides detailed information about commonly monitored water quality parameters and guidance on selecting appropriate parameters to monitor for a given application. It also provides a summary of available technologies for monitoring each parameter.
https://www.epa.gov/waterqualitysurveillance/online-water-quality-monitoring-resources

**List of Available Online Water Quality Monitoring Instruments (EPA, 2017)**

This spreadsheet provides general information related to OWQM instruments that utilities can use to identify instruments that are capable of satisfying OWQM system requirements.
https://www.epa.gov/waterqualitysurveillance/online-water-quality-monitoring-resources

**Online Distribution System Water Quality Monitoring for Water Quality Surveillance and Response Systems (EPA, 2017)**

This document provides guidance for designing a real-time distribution system water quality monitoring system to achieve a variety of design goals, including monitoring for contamination incidents and optimizing distribution system water quality. (EPA 817-B-19-001, April 2018)
https://www.epa.gov/waterqualitysurveillance/online-water-quality-monitoring-resources

**Online Source Water Quality Monitoring for Water Quality Surveillance and Response Systems (EPA, 2016)**

This document provides guidance for designing a real-time source water quality monitoring system to achieve a variety of design goals, including treatment process optimization, detection of source water contamination incidents, and monitoring threats to long-term source water quality.
https://www.epa.gov/sites/production/files/2016-09/documents/online_source_water_monitoring_guidance.pdf

**Online Water Quality Monitoring Primer (EPA, 2015)**

This document provides an overview of the OWQM component and presents information about the goals and objectives of OWQM in the context of an SRS. (EPA 817-B-15-002A, May 2015.)
https://www.epa.gov/sites/production/files/2015-06/documents/online_water_quality_monitoring_primer.pdf

**Water Quality Surveillance and Response System Primer (EPA, 2015)**

This document provides an overview of SRSs, and serves as a foundation for the use of technical guidance and products used to implement an SRS. (EPA 817-B-15-002, May 2015.) https://www.epa.gov/sites/production/files/2015-06/documents/water_quality_sureveillance_and_response_system_primer.pdf

# Glossary

**alert**. An indication from an SRS surveillance component that an anomaly has been detected in a datastream monitored by that component. Alerts may be visual or audible, and may initiate automatic notifications such as pager, text, or email messages.

**anomaly**. A deviation from an established baseline in a monitored datastream. Detection of an anomaly by an SRS surveillance component generates an alert.

**benefit**. An outcome associated with the implementation and operation of an SRS that promotes the welfare of a utility and the community it serves. Benefits can be derived from a reduction in the consequences of a contamination incident and from improvements to routine utility operations.

**control center**. A utility facility that houses operators who monitor and control treatment and distribution system operation, as well as other personnel with monitoring or control responsibilities. Control centers often receive system alerts related to operations, water quality, security, and some of the SRS surveillance components.

**dry pit**. A man-made pit consisting of a rock layer covered by a dirt layer that allows for OWQM station waste streams to be discharged and naturally treated before percolation. Dry pits are often used when sewer lines are not available.

**installation site.** The specific area where an OWQM station is installed (e.g., a utility facility closet or fire station basement). Installation sites provide the physical space, sample water source, waste stream outlet, power source, and data communications access required for stations to function.

**Online Water Quality Monitoring (OWQM)**. One of the surveillance components of an SRS. OWQM utilizes data collected from monitoring stations that are deployed at strategic locations in a source water or a distribution system. Monitored parameters can include common water quality parameters (e.g., pH, specific conductance, turbidity) and advanced parameters (e.g., total organic carbon, spectral absorbance). Data from monitoring stations is transferred to a central location and analyzed.

**reagent**. A chemical substance used to cause a reaction for the purpose of chemical analysis.

**real-time.** A mode of operation in which data describing the current state of a system is available in sufficient time for analysis and subsequent use to support assessment, control, and decision functions related to the monitored system.

**sensor**. The part of a water quality instrument that performs the physical measurement of a water quality parameter in a sample.

**sensor malfunction**. A condition in which the data produced by a sensor unit does not reflect actual conditions.

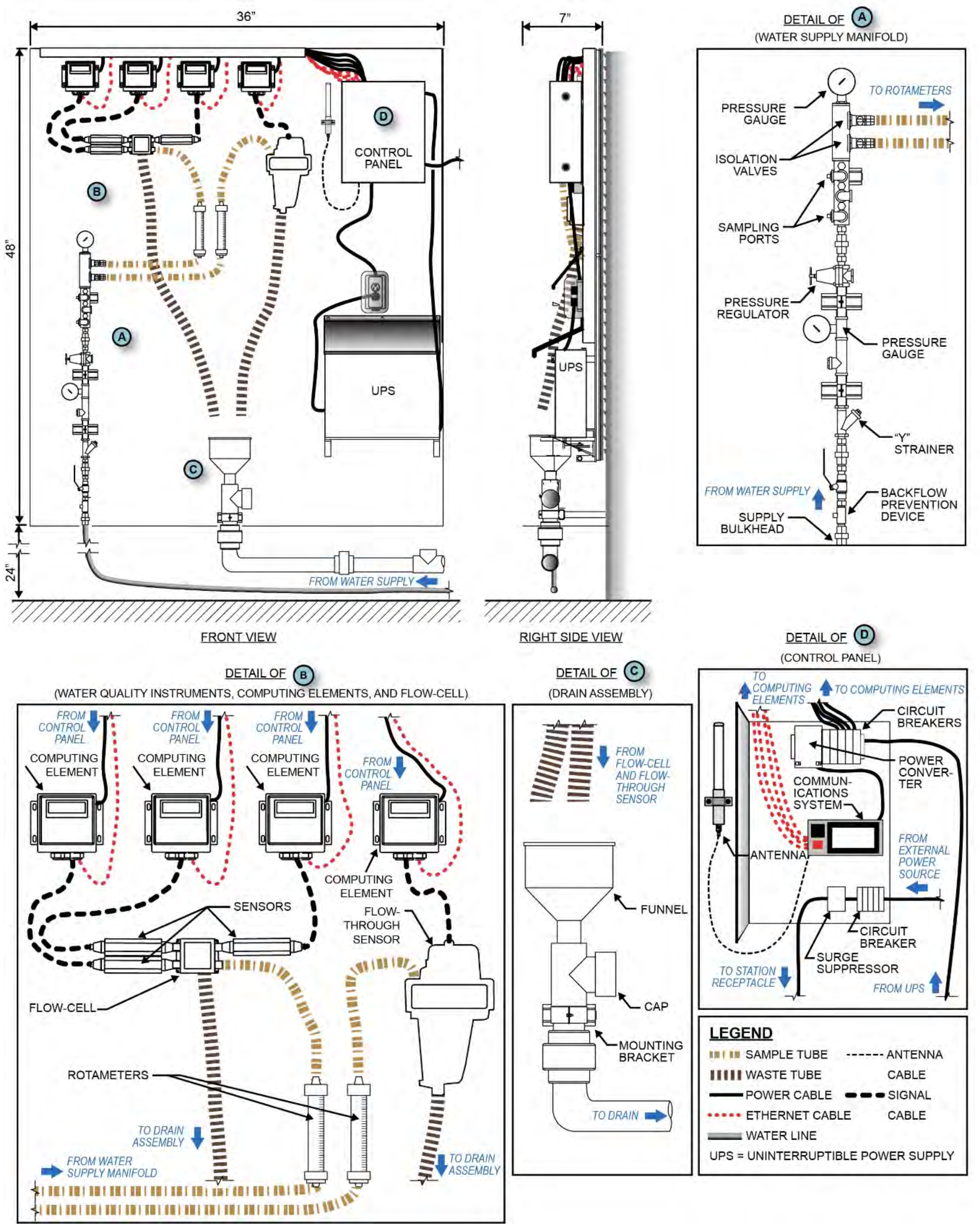
**turbidity**. The cloudy appearance of water caused by the presence of suspended particles.

**water quality incident**. An incident that results in an undesirable change in water quality (e.g., low residual disinfectant, rusty water, taste & odor, etc.). Contamination incidents are a subset of water quality incidents.

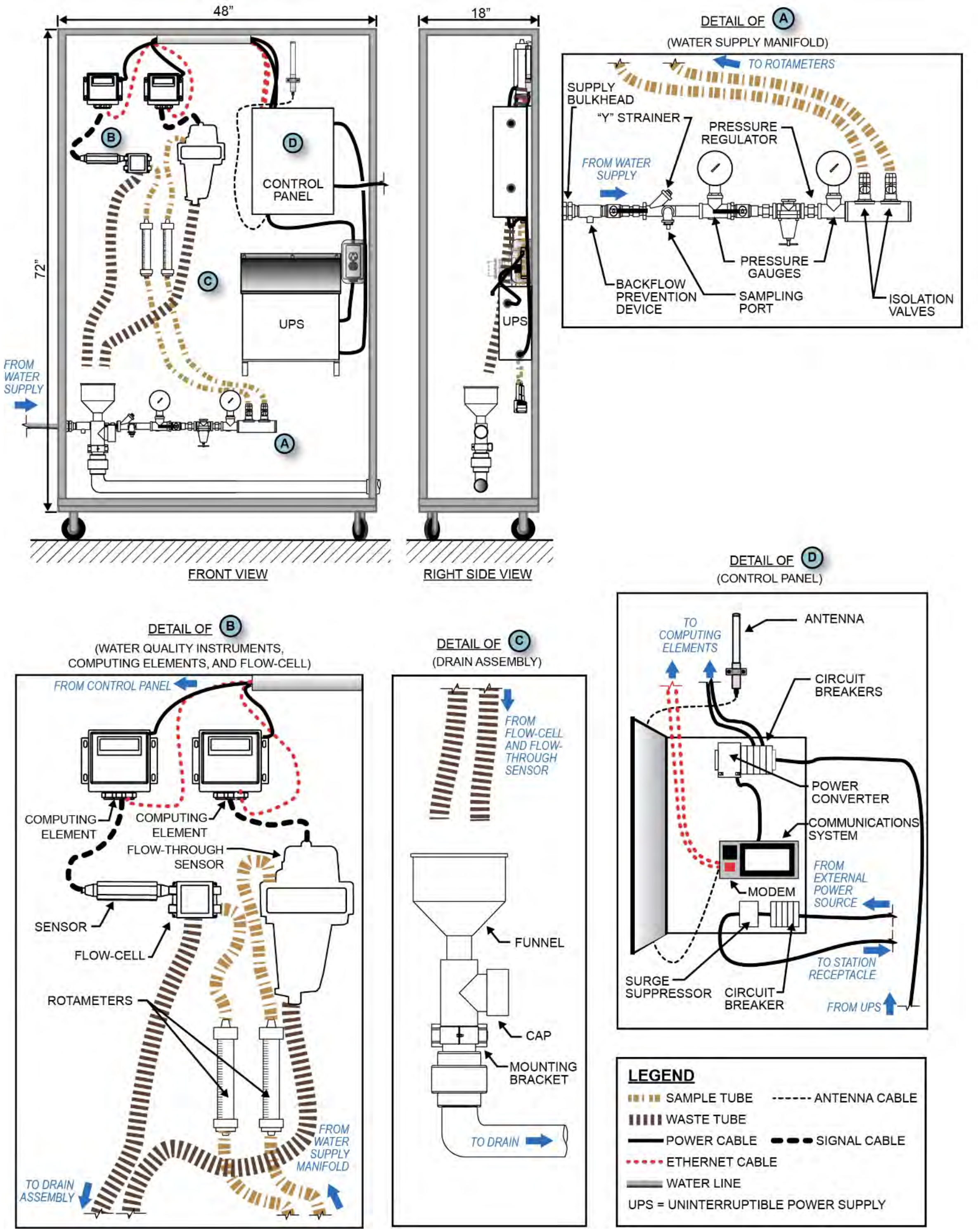
**water quality instrument.** A unit that includes one or more sensors, electronics, internal plumbing, displays, and software that is necessary to take a water quality measurement and generate data in a format that can be communicated, stored, and displayed. Some instruments also include diagnostic tools.

**Water Quality Surveillance and Response System (SRS)**. A system that employs one or more surveillance components to monitor and manage source water and distribution system water quality in real time. An SRS utilizes a variety of data analysis techniques to detect water quality anomalies and generate alerts. Procedures guide the investigation of alerts and the response to validated water quality incidents that might impact operations, public health, or utility infrastructure.

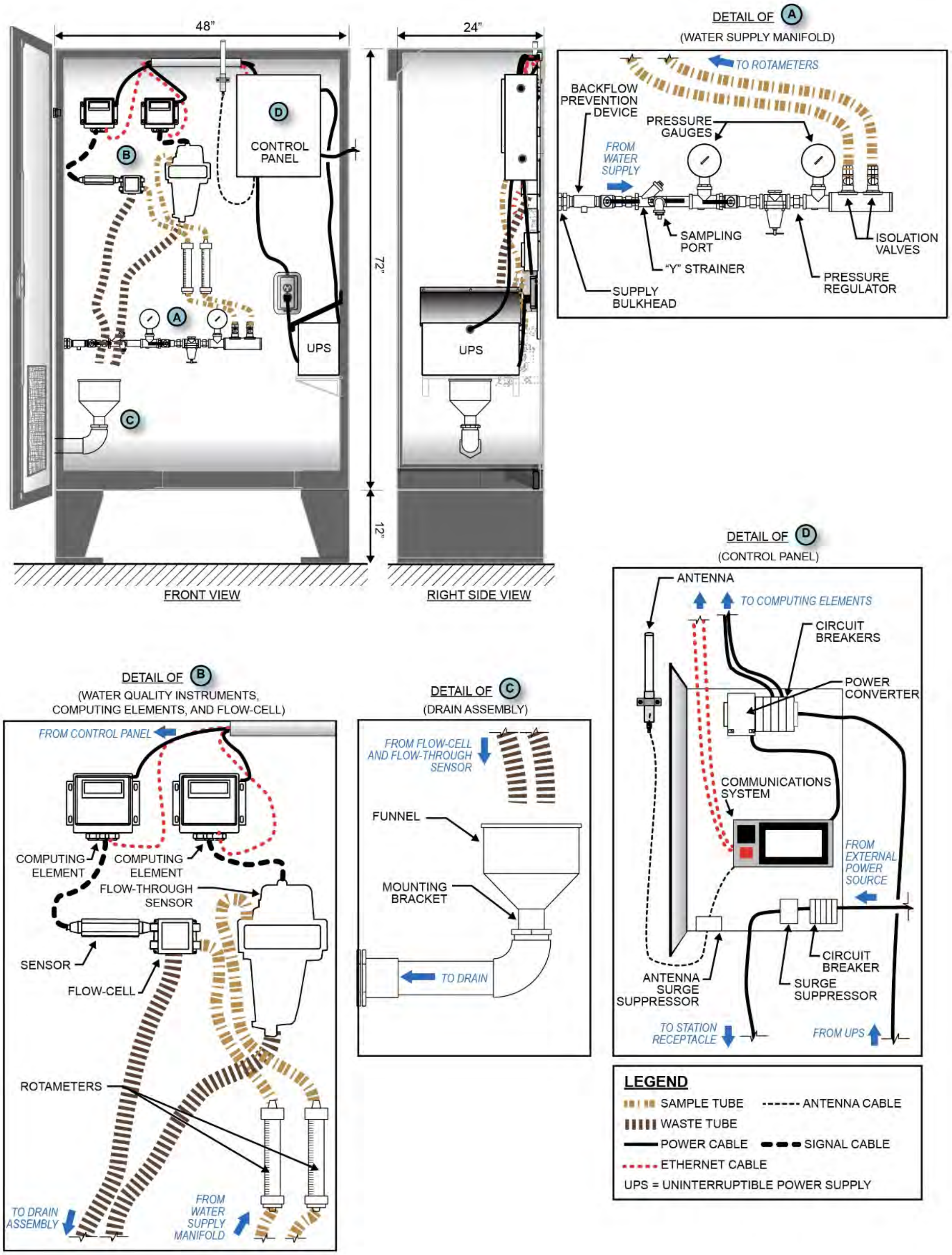
# Appendix A: Wall-Mounted Rack Schematic



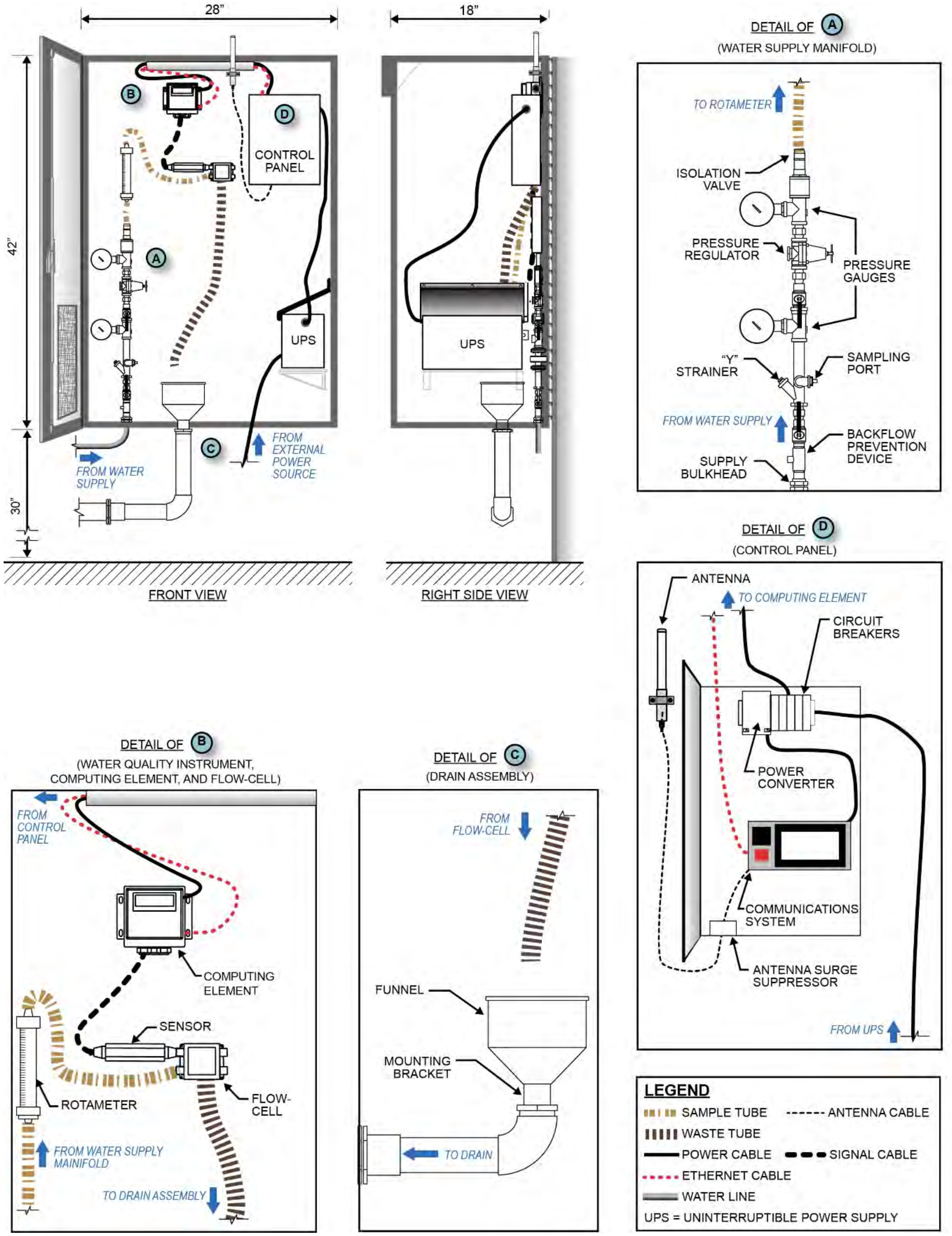
# Appendix B: Free-Standing Rack Schematic



# Appendix C: Enclosed Station Schematic



# Appendix D: Compact Station Schematic



# Appendix E: Floating Platform Schematic