WaterSense at Work

Water Use Monitoring

2.1 Metering and Submetering

Best Management Practices for Commercial and Institutional Facilities

EPA WaterSense

November 2023

WaterSense® is a voluntary partnership program sponsored by the U.S. Environmental Protection Agency (EPA) that seeks to protect the nation's water supply by transforming the market for water-efficient products, services, and practices.

WaterSense at Work is a compilation of water efficiency best management practices intended to help commercial and institutional facility owners and managers from multiple sectors understand and better manage their water use. It provides guidance to help establish an effective facility water management program and identify projects and practices that can reduce facility water use.

An overview of the sections in *WaterSense at Work* is below. This document, covering water metering and submetering, is part of **Section 2: Water Use Monitoring**. The complete list of best management practices is available at www.epa.gov/watersense/best-management-practices. WaterSense has also developed worksheets to assist with water management planning and case studies that highlight successful water efficiency efforts of building owners and facility managers throughout the country, available at www.epa.gov/watersense/commercial-buildings.

EPA 832-F-23-003
Office of Water
U.S. Environmental Protection Agency
November 2023

This document is one section from *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities* (EPA-832-F-23-003). Other sections can be downloaded from www.epa.gov/watersense/best-management-practices. Sections will be reviewed and periodically updated to reflect new information. The work was supported under contract 68HERC20D0026 with Eastern Research Group, Inc. (ERG).

Overview

Water meter box cover

An important rule in water management is that you can't manage what you don't measure. Tracking a facility's total water use, as well as specific end uses, is key to successful commercial and institutional facility water efficiency efforts. Meters typically measure the amount of water being supplied to a campus or facility, while submeters measure usage for tenant spaces or specific activities, such as cooling tower, process, or landscape water use. Accurately measuring water use can help facility owners and operators identify areas for targeted reductions and track progress from water efficiency upgrades. Submeters can also help identify leaks and indicate when equipment is malfunctioning.

Meters and submeters can be integrated into a centralized building management system, making it easy to track usage and implement a water management plan (refer to *WaterSense at Work Section 1.2: Water Management Planning* at www.epa.gov/watersense/best-management-practices for more information). These systems are capable of electronically storing data from meters and submeters, reporting hourly, daily, monthly, and annual water use. They can also trigger alerts when leaks or other operational anomalies are detected.

Metering

For the purposes of this section, the term "metering" refers to the use of water meters owned and managed by a utility to measure the total volume of water supplied to a campus or facility. Meters measure and record usage data periodically for use in customer billing and are typically associated with a single utility account.

Understanding Current Meter Infrastructure and Capabilities

A good first step in developing a water management program is understanding the water meter infrastructure in place at a facility. Water meters supplied by a facility's water utility

can typically be characterized as either a conventional (i.e., standard) water meter or an advanced meter.

Conventional water meters require data to be retrieved by the utility on a periodic basis—typically monthly or quarterly—for billing purposes. This infrequency of data collection makes it more challenging for facility owners and operators to monitor water use and respond quickly to problems.

Advanced water meters record and transmit data automatically. Advanced meters record consumption data at least hourly and provide for daily—or more frequent—transmittal of data to a central collection point. [1] Advanced meters can provide detailed, real-time water use measurements that can allow problematic trends and anomalies to be quickly identified. While often used interchangeably with "advanced metering," the term "smart meter" typically refers to a specific subset of advanced meters that is capable of communicating readings to utilities for processing and analysis and sending billing and consumption data back to the customer. Smart meters also typically provide additional functions such as remote connect/disconnect, tamper detection, and outage monitoring.

All water conveyed to a facility should be metered, regardless of the source. Even if a facility's water is supplied solely by an alternative source (e.g., municipally supplied reclaimed water), a meter should still be installed to track and manage water use. If multiple sources of water are supplied to a facility, each source should be metered separately.

There may also be benefits in installing sewer meters or sewer deduct meters. Some wastewater utilities offer a sewer credit or deduction based on water that does not enter the sanitary sewage system. Typically, sewer usage is not separately metered at the facility level. Therefore, most utilities estimate sewer charges based on the metered water usage. This arrangement assumes that all the water that enters the property via the source water meter leaves the property by the sanitary sewer system. In practice, however, some of the water that is delivered to the property may not leave the property (e.g., landscape irrigation water) or may not leave the property through the sewer system (e.g., evaporated cooling tower water). Other examples include swimming pool water and water used in the manufacturing or processing of goods. Installing deduct meters on activities such as these can reduce sewer charges from participating utilities. Facility owners and operators should reach out to their local utility providers to determine if a sewer deduction is offered and to understand any metering and reporting requirements.

Although meter installation and management typically fall within the purview of the utility rather than the customer, having a suitable meter and ensuring that it is properly functioning are critical to accurate water measurement. There are many types and sizes of meters intended for different uses, so it is important that your facility is properly equipped

[1] U.S. Department of Energy (DOE), Federal Energy Management Program (FEMP). October 2022. *Federal Metering Guidance*. www.energy.gov/femp/articles/federal-metering-guidance-energy-act-2020-sec-1002g.

with an appropriate one. Improper sizing or type can cause problems for the building. For example, an undersized water meter can cause excessive pressure loss, reduced flow, and noise. Oversized meters are not economical and do not accurately measure minimal flow rates. [2] In addition, many utilities charge customers a fixed fee based on the size of the installed meter, so it is important to ensure that a facility's water meter is not oversized. All utility-grade water meters manufactured and installed for domestic water service by a water utility in the United States must comply with American Water Works Association (AWWA) standards.

Accessing and Utilizing Meter Data

If a facility is only equipped with a conventional water meter, facility owners and operators can still monitor periodic consumption and cost data to:

- Verify utility bills;
- Compare utility rates;
- Manage budgets by assessing the impact of utility price fluctuations; and
- Identify long-term trends or anomalies such as sizeable leaks.

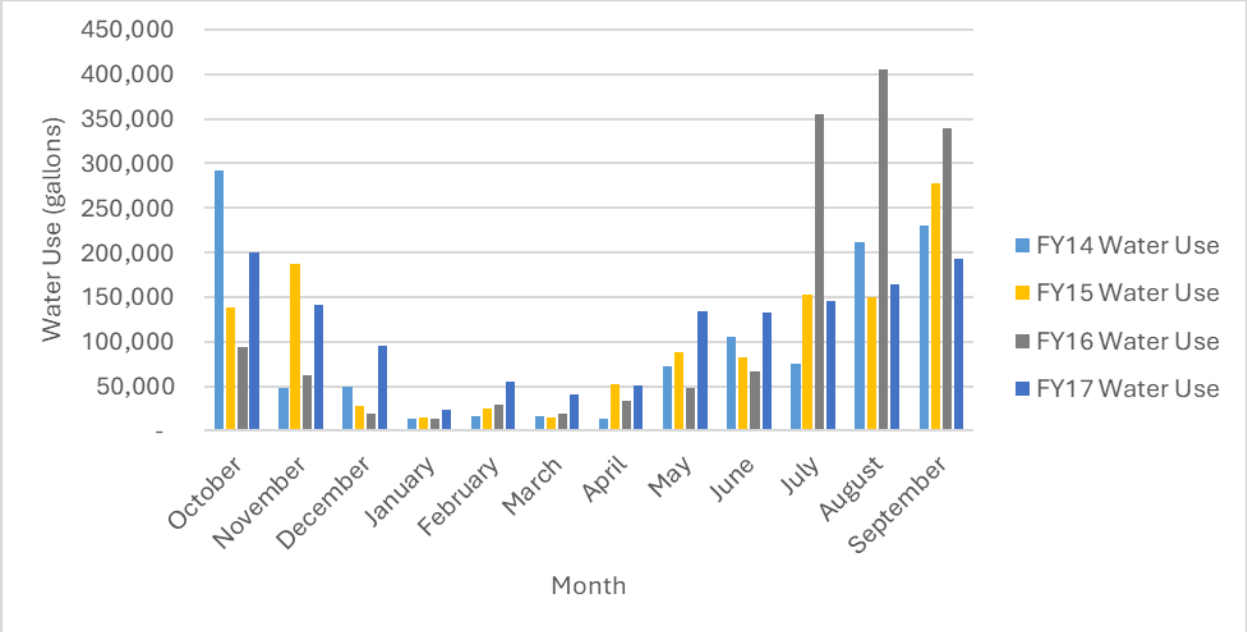


Figure showing monthly water use tracked from meter data. By monitoring meter data, anomalies can be identified, such as higher-than-normal water use over the summer of 2016 indicating presence of a potential leak.

[2] American Water Works Association (AWWA). 2012. *Water Meters—Selection, Installation, Testing, and Maintenance* (AWWA Manual M6, Fifth Edition).

Facilities equipped with conventional meters should consider installing submeters, as described later in this section, or other water use monitoring devices such as data loggers. Data loggers are portable compact devices that can be used to retrieve and evaluate data more regularly to supplement utility-managed water meters. They are generally battery-operated, stand-alone tools containing a microprocessor, memory, and sensors for measuring and recording one or more variables over time. Data loggers have the advantages of being relatively affordable and easy to install as a retrofit to existing meters to directly collect data. Some companies offer companion software to help with data visualization and trend analysis.

Advanced water meters—which are part of advanced metering infrastructure (AMI) operated by many water utilities—allow for data collection to occur more frequently and effortlessly, facilitating the transformation of meter readings into actionable data. Data acquired from advanced meters are sent via wired or wireless communication to a remote database. Facility owners or other users can subsequently access data through a customer portal or online platform. If a water utility has already installed advanced or smart meters at the facility, facility owners and operators should work with the utility to gain access to the customer portal and begin monitoring water consumption more regularly. If a customer portal does not exist, some water utilities may still be willing to work with commercial customers to provide interval water consumption data. Some utilities also offer leak detection services that are generated through advanced water meters.

What is Advanced Metering Infrastructure?

Advanced metering infrastructure (AMI) refers to integrated systems that measure, collect, and analyze energy and water usage data. AMI includes hardware (e.g., meters, sensors, alarms, displays), software, and communications infrastructure. In addition to the water meter, AMI hardware may also include the following:

- **Meter interface units (MIUs)**, which serve as the gateway between meters and the data communications network, transmitting the onsite data and analytics to an information management system. MIUs typically consist of a battery and a computer chip or radio transmitter.
- **Sensors**, including water quality monitors, pressure sensors, temperature sensors, and other types. Along with consumption data, some of this information may be available within a customer portal.
- **Remotely controlled valves**, which can be used to shut off or turn on water service for customers.

Find out more about AMI within EPA's *Using Advanced Metering Infrastructure in a Water Quality Surveillance and Response System* at www.epa.gov/sites/default/files/2021-03/documents/srs_ami_guidance_20210223_508_complete.pdf.

The Energy Act of 2020 requires that all federal buildings be metered using advanced meters or advanced metering devices where practicable (42 U.S.C. § 8253(e)). Additional

information can be found in the Federal Energy Management Program's (FEMP's) *Federal Metering Guidance*.[3]

Reviewing and understanding the data collected and communicated through AMI may prevent the need for submetering within a facility. If the water utility does not have advanced or smart meters installed, consider adding submeters. For more information about using AMI to assist with water management, see WaterSense's AMI guide, *Improving Water Management Using Advanced Metering Infrastructure Data: A Guide for Facility Managers* at www.epa.gov/watersense/advanced-metering-infrastructure.

Submetering

Reading facility submeters

For the purposes of this chapter, the term "submetering" refers to the use of facility-owned water metering equipment to measure a subset of total water use within individual buildings on a campus, tenant spaces, or specific water-intensive activities. Submeters allow facility owners and operators to track water usage more precisely. As opposed to meters, which primarily collect billing data for utilities, submeters are designed with water efficiency and operational improvement in mind. In most cases, submeters do not require separate utility accounts, and therefore should not result in any meter connection fees or ongoing meter charges from the water utility. A facility can install and monitor submeters on its own to understand and manage its water use.

Benefits of Submetering

Since utility-owned meters typically only measure the total volume of water supplied to a property, submeters are often needed to monitor specific water-intensive buildings and activities (e.g., irrigation, cooling). Submetering provides facility owners and operators with information that can be used to optimize building and equipment operations. Recent advances in metering technologies and information systems have improved functionality and decreased costs, allowing real-time usage data to be collected in a more cost-effective manner. If properly monitored and managed, these data can be used to:

- Improve equipment operations and reliability.
- Quickly identify and respond to leaks and equipment malfunctions.

[3] DOE, FEMP, *op. cit.*

- Prolong equipment life (and subsequently reduce capital investments).
- Properly allocate costs to tenants.
- Identify water efficiency improvement opportunities.
- Measure and verify water efficiency improvement projects.
- Benchmark building water use.
- Support efforts to obtain green building certifications.

The activities listed above can reduce water use, reduce costs for water and wastewater, and improve overall building operations.

As with meters, submeters and associated infrastructure can provide for periodic and automatic data retrieval. Data can be sent to a remote database for analysis and translation into actionable recommendations.

Determining What to Submeter

Facility owners and operators should consider installing separate submeters to measure specific end uses that are permanently plumbed, as indicated in Table 1 on the next page. For more information and additional recommendations on metering and submetering, review the U.S. Green Building Council's LEED® rating systems and the International Green Construction Code® (IgCC®).[4,5,6]

Submeter used to monitor reverse osmosis system

Building owners and property managers intending to use submeters to bill tenants for water usage should be sure to understand state and local regulations. Whether or not

[4] U.S. Green Building Council (USGBC). LEED Operations and Maintenance (O+M): Existing Buildings. Version 4. Water Metering Credit. www.usgbc.org/credits/existing-buildings-retail-existing-buildings-schools-existing-buildings-hospitality?return=/credits/Existing%20Buildings/v4.
[5] USGBC. LEED Building Design and Construction (BD+C): New Construction. Version 4 and Version 4.1. Water Metering Credit. www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-1?return=/credits/New%20Construction/v4.1.
[6] International Code Council. *2021 International Green Construction Code*. https://codes.iccsafe.org/content/IGCC2021P2/preface.

submetering is permitted and specific requirements related to tenant billing can vary depending on the locality. [7]

Table 1. Submetering Recommendations

Submeter Application	Recommendation
Tenant Spaces	Meter all tenant spaces individually.
Cooling Towers	Meter cooling tower make-up water and blowdown water supply lines. A single make-up meter and a single blowdown meter can record flows for multiple cooling towers if they are controlled with the same system. Separately controlled cooling towers should have separate make-up and blowdown water meters.
Heating, Ventilating, and Air Conditioning (HVAC) Systems	Individually or collectively meter HVAC systems with aggregate annual water use of 100,000 gallons (379 kiloliters) or more or if the facility has 50,000 square feet (4,600 square meters) or more of conditioned space. Metered systems should include evaporative coolers, humidifiers, mist cooling devices, and recirculating water systems with a water connection, such as chilled water, hot water, and dual temperature systems.
Steam Boilers	Meter the make-up water supply line to steam boilers with a rating of 500,000 British thermal units (Btus) per hour or greater. A single make-up meter can record flows for multiple boilers.
Single-Pass Cooling Systems	Meter any systems or equipment that use single-pass cooling water and do not use a chilled water system or closed loop recirculation.
Irrigation	Meter irrigation systems that are automatically controlled.
Roof Spray Systems	Meter roof spray systems for irrigating vegetated roofs or thermal conditioning.
Ornamental Water Features	Meter make-up water supply lines for ornamental water features with a permanently installed water supply.
Pools and Spas	Meter make-up water supply lines for indoor and outdoor pools and spas.
Industrial Processes	Individually meter industrial processes consuming more than 1,000 gallons (3,800 liters) of water per day on average.
Alternative Water Sources	Meter water use from alternative water sources, such as gray water, rainwater, air handler or boiler condensate, or other sources discussed in *WaterSense at Work Section 8: Onsite Alternative Water Sources* at www.epa.gov/watersense/best-management-practices.
Other Processes	Meter any other process with a projected water use of 1,000 gallons (3,800 liters) or more per day or 100,000 gallons (379 kiloliters) or more per year.

[7] National Conference of State Legislatures. January 15, 2016. Utility Submetering. www.ncsl.org/energy/utility-submetering.

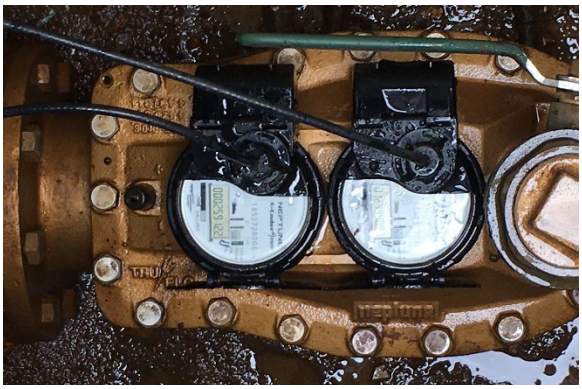
Selecting Submeters

While the basic function of all water meters is to convert the physical flow of water into a measurement of volume, a wide variety of meter designs and sizes are available in the market. It is important to choose a meter that is suitable for the intended use. Submeters that are installed for water management purposes and not used for revenue purposes are not subject to AWWA standards.

In selecting the appropriate submeter size, it is critical to understand the building's size, function, fixture types, usage occupancy, and peak population. These factors determine the minimum and maximum flow rates and will assist in the selection of a properly sized water meter. AWWA Manual M22, *Sizing Water Service Lines and Meters*, provides additional guidelines for selecting and sizing utility-owned and installed water meters. [8] Although this manual is intended primarily to inform the selection of utility-scale meters, it may also be helpful in selecting and sizing submeters.

The appropriate meter type can be determined based on the intended use and flow rate. Common meter technologies include the following:

- **Positive displacement meters**. Positive displacement meters directly measure water volume by evaluating the rate at which a fluid mechanically displaces a chamber. They are best suited for small commercial or institutional applications because they have high accuracy rates at low flows and can precisely measure peak flows.
- **Velocity meters**. Velocity meters such as turbine and propeller meters measure water velocity and convert the measurement into volume. They are most appropriate for continuous, high-flow applications and can be inaccurate at low flows. These types of meters are not usually recommended for commercial, institutional, or residential buildings because water flows are in constant fluctuation, with very low minimum flow rates.
- **Compound meters**. Compound meters integrate a positive displacement chamber for low flows and a turbine chamber for high flows. They are good for large commercial or institutional facilities because they accurately measure across a range of low flows and high flows.
- **Electronic meters**. Electronic meters include electromagnetic meters and ultrasonic flow meters.



Compound meter for reading both high and low flows

[8] AWWA. 2014. *Sizing Water Service Lines and Meters* (AWWA Manual M22, Third Edition).

Electromagnetic meters use magnetic fields to induce an electrical current that is proportional to the water flow rate. Ultrasonic flow meters—sometimes known as acoustic flow meters—use ultrasonic acoustic vibrations to calculate flow rate based on transit time or frequency shift. Electronic meters can be installed in-line or clamped onto the exterior of a pipe and can be used in most commercial applications regardless of the type of flow. They are ideal for measuring wastewater or corrosive liquids without damage to sensors. Clamp-on models are non-intrusive, low-maintenance, and do not cause a pressure drop in the water supply. Portable models can be used to spot-check flow rates throughout a facility during a water assessment or routine monitoring.

- **Differential pressure meters**. Differential pressure meters, including Venturi meters and orifice plate meters, work by restricting flow into the meter and measuring the difference in pressure between the inlet and outlet. Differential pressure meters are commonly found in large water distribution systems, since they are ideal for applications with high-flow and low-flow variation. They are typically less expensive than other types of meters but require sufficient space.

When planning to submeter hot water use, consider selecting a meter intended for that application.

Pacific Northwest National Laboratory's *Water Metering Best Practices* guide includes a summary table comparing the characteristics of various metering technologies including cost, flow range, meter size, typical applications, and other attributes.[9]

Some commercial vendors offer water monitoring programs or devices that are available either in addition to or instead of water meters and submeters. These devices can be connected to existing water meters or installed within the water line to help monitor water usage and flow in real time. These devices can collect and store water use data and assist facility owners and operators in tracking water use on a more regular basis than is permitted through monthly utility bills. Many companies also offer a dashboard or other management software to assist in analyzing water use trends, recommending areas to improve efficiency, and generating reports. Further, these devices can be customized to send alerts during periods of high or unexpected water use, during continuous flow events, or when leaks are otherwise suspected. See *WaterSense at Work Section 2.2: Leak Detection and Repair* at www.epa.gov/watersense/best-management-practices for more information.

Installing and Maintaining Submeters

Following is a list of installation and maintenance best practices to ensure optimal submeter operation:

[9] Pacific Northwest National Laboratory. February 2022. *Water Metering Best Practices.* Prepared for DOE. Table 1. www.pnnl.gov/main/publications/external/technical_reports/PNNL-32074.pdf.

- When installing a submeter, follow the manufacturer's instructions. Improper installation can lead to metering inaccuracies.
- Ensure submeters are installed downstream of (after) the main water utility meter so as not to affect utility-owned piping or the utility's ability to measure a facility's total water use.
- Install submeters in an accessible location to allow for reading and repair. In addition, ensure that the submeter location is protected from potential damage.
- To ensure uniform flow entering the submeter, do not install the submeter near pipe bends. In general, place the submeter in a location with a straight length of pipe equivalent to at least 10 times the pipe diameter downstream of the meter and five times the pipe diameter upstream of the submeter. [10]
- Create a map indicating the location of all water supply meters and submeters to be included in the facility water management plan.
- Include a strainer on all meters and submeters. Debris and sediment can enter a meter and have an adverse effect on accurate measurement. An inline strainer on the meter's inlet will collect debris and sediment and prevent it from entering the meter body. [11]
- Since meters deteriorate with age, test them for accuracy and calibrate them on a regular basis. AWWA recommends that utility-owned meters be tested, on average, as follows: [12]
    - Meter sizes 5/8 to 1 inch: Every 10 years
    - Meter sizes 1 to 4 inches: Every five years
    - Meter sizes 4 inches and larger: Every year
- Inspect and calibrate submeters according to manufacturer recommendations, or more frequently, depending upon the type and size of the meter and its application.

Water Use Tracking and Integration Into the Water Management Plan

Facility owners and operators should consider installing a water meter data management system with remote communication capabilities that provides instant feedback on all metered water use in a central location. This type of system makes it easier for facility owners and operators to identify leaks or other abnormalities and better understand and manage water use at the facility.

[10] AWWA 2012, *op. cit.*
[11] *Ibid.*
[12] Georgia Environmental Protection Division. August 2007. *Water Meter Calibration, Repair, and Replacement Program*. Page 7. www1.gadnr.org/cws/Documents/Meter_Repair_Replacement.pdf.

A variety of programs and software are available to help analyze and visualize time-interval water use data, including ENERGY STAR® Portfolio Manager®. Portfolio Manager is a free interactive tool for managing the energy, water, waste, and greenhouse gas emissions of any building type. The tool allows users to enter meter-level data based on monthly or annual billing cycle. Once data is input into Portfolio Manager, there are tools to understand metrics, monitor trends, and generate reports.

If the facility is not integrating metering data into a centralized data system, consider the following best practices:

- Assign responsibility to track water use at least monthly.
- Ensure that staff understand how to read the meters and record data properly. Pay special attention to the units that the meter uses—gallons, cubic feet, and hundred cubic feet are common units for water meters. Also, ensure that staff record the numerical values properly. Meters often include one or more trailing zeros that must be added after the numerical dial reading.
- Plot total water use and submetered data monthly and examine data for unexplained fluctuations.
- Evaluate trends and investigate and resolve any unexpected deviations in water use.

This meter reads 201,670 cubic feet

Additional Resources

American Water Works Association (AWWA). 2012. *Water Meters—Selection, Installation, Testing, and Maintenance* (AWWA Manual M6, Fifth Edition).

AWWA. 2014. *Sizing Water Service Lines and Meters* (AWWA Manual M22, Third Edition).

U.S. Department of Energy (DOE), Federal Energy Management Program (FEMP). October 2022. *Federal Metering Guidance*. www.energy.gov/femp/articles/federal-metering-guidance-energy-act-2020-sec-1002g.

DOE, FEMP. Water Metering Resources. www.energy.gov/femp/water-metering-resources.

EPA's WaterSense program. September 2022. *Improving Water Management Using Advanced Metering Infrastructure: A Guide for Facility Managers*. www.epa.gov/watersense/advanced-metering-infrastructure.

National Conference of State Legislatures. January 15, 2016. Utility Submetering. www.ncsl.org/energy/utility-submetering.

National Science and Technology Council. October 2011. *Submetering of Building Energy and Water Usage: Analysis and Recommendations of the Subcommittee on Buildings Technology Research and Development*. https://sftool.gov/Content/attachments/submetering_of_building_energy_and_water_usage.pdf.

Pacific Northwest National Laboratory (PNNL). March 1, 2015. *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Release 3.0*. Prepared for DOE. www.wbdg.org/ffc/doe/national-laboratory-criteria/metering-best-practices.

PNNL. February 2022. *Water Metering Best Practices*. Prepared for DOE. www.pnnl.gov/main/publications/external/technical_reports/PNNL-32074.pdf.

This page intentionally left blank.

Disclaimer

United States Environmental Protection Agency
(4204M)
EPA 832-F-23-003
November 2023
www.epa.gov/watersense
(866) WTR-SENS (987-7367)