Water Efficiency Management Guide for Bathroom Suites

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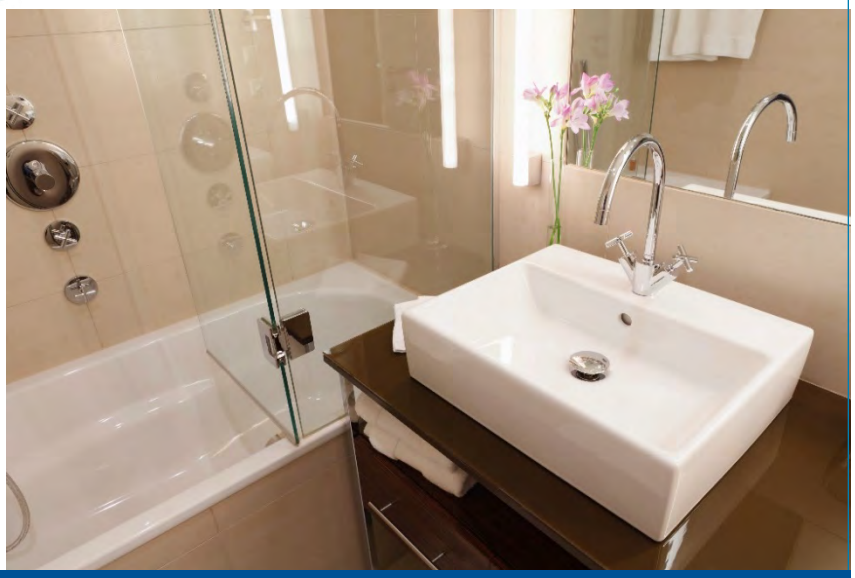
Elie Tawil, P.E., LEED AP

Continuing Education and Development, Inc.

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

EPA WaterSense



Water Efficiency Management Guide

Bathroom Suite

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The U.S. Environmental Protection Agency (EPA) WaterSense® program encourages property managers and owners to regularly input their buildings' water use data in ENERGY STAR® Portfolio Manager®, an online tool for tracking energy and water consumption. Tracking water use is an important first step in managing and reducing property water use.

WaterSense has worked with ENERGY STAR to develop the EPA Water Score for multifamily housing. This 0-100 score, based on an entire property's water use relative to the average national water use of similar properties, will allow owners and managers to assess their properties' water performance and complements the ENERGY STAR score for multifamily housing energy use.

This series of Water Efficiency Management Guides was developed to help multifamily housing property owners and managers improve their water management, reduce property water use, and subsequently improve their EPA Water Score. However, many of the best practices in this guide can be used by facility managers for non-residential properties.

More information about the Water Score and additional Water Efficiency Management Guides are available at www.epa.gov/watersense/commercial-buildings.

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Background

Bathrooms offer a clear opportunity for properties to save significant amounts of water. Use of toilets, faucets, showerheads, and other sanitary fixtures in the bathroom suite typically represent a significant percentage of water use in properties. Beyond user behavior (i.e. how frequently and for what duration products are used), the inherent efficiency of plumbing fixtures and how the products wear over time also impact bathroom water consumption. You can influence tenant water and sewer needs and costs by using sound maintenance practices in addition to opting for water-efficient products during renovations. Replacing bathroom fixtures with water-efficient products—and WaterSense labeled products when applicable—can provide the most significant opportunity for water and energy savings, particularly in older buildings with inefficient fixtures.

The first step to identifying potential water savings is to verify the flow rates and flush volumes of each fixture in your units' bathrooms. Older products have the most room for improvement—not only do they typically use more water than newer products, but maintenance issues are also magnified. By replacing older fixtures with newer, WaterSense labeled models, you'll save on both water bills and maintenance, all while delivering a more consistent product for your residents.

The Energy Policy Act (EPAct) of 1992 sets the maximum flow rates and flush volumes for many bathroom fixtures, so the date of installation usually corresponds with a particular level of water efficiency. For example, toilets installed after 1994 will have a flush volume of 1.6 gallons per flush (gpf) or less. However, due to the long, useful life of toilets, many older toilets still in use today have flush volumes of 3.5 gpf and up to 5.0 gpf.

The U.S. Environmental Protection Agency's (EPA's) WaterSense® program labels certain bathroom fixtures that are at least 20 percent more water-efficient than standard plumbing products on the market (as established by EPAct 1992). WaterSense labeled products are also independently certified to perform as well or better than standard models.

Table 1. Maximum Allowable Flow Rate and Flush Volume Requirements by Standard

Fixture Type	Pre-EPAct 1992	Post-EPAct 1992 Requirement	WaterSense Requirement
Bathroom sink (lavatory) faucet	Up to 2.5 gallons per minute (gpm)	2.2 gpm	1.5 gpm
Showerhead	3.0 to 5.0 gpm	2.5 gpm	2.0 gpm
Tank-type toilet	3.5 to 5.0 gpf	1.6 gpf	1.28 gpf
Flushometer-valve toilet	3.5 to 5.0 gpf	1.6 gpf	1.28 gpf

Maintenance Best Management Practices

Performing periodic inspections in the bathroom suite will help keep equipment working and catch water waste before it impacts your water bill. Aim to conduct inspections at least annually, or consider how checks might be incorporated into other natural intervention points, such as during tenant changes. Each fixture type has certain common issues to examine and verify. Table 2 provides a summary of inspection items that should be performed periodically.

Table 2. Bathroom Fixture Maintenance Tips for Periodic Inspections

Product Type	Tip	Why
Tank-type toilets	Check the toilet fill valves for water overflow. Remove the toilet tank lid and determine if water is flowing over the top of the overflow tube inside the tank. Ensure that the refill water level is set below the top of the overflow tube, and adjust the float lower if the water level is set too high. If the toilet continues to run after the float is adjusted, replace the fill valve. To prevent changes in tank water levels due to line water pressure fluctuations, only replace existing fill valves with pilot-type fill valves.	A constantly running fill valve can waste between 0.5 gallons per minute (gpm)[1] and 3 gpm, wasting up to 4,000 gallons of water[2] and as much as $45 per day.[3]
Tank-type toilets	Perform dye test to look for worn toilet flappers. Drop a dye tablet or a few drops of food coloring into the toilet tank. After 10 minutes, check if the dye leaked into the bowl, which indicates a flapper leak. Flush the toilet immediately after conducting this test to prevent the dye from staining the tank or bowl. If there is a leak, check for a tangled chain in the tank or replace a worn flapper valve. If leaking does not subside after a flapper valve is replaced, consider replacing the flapper seat and overflow tube assembly, which could also be worn.	While leaks from worn toilet flappers may be hard to detect, even small leaks can waste approximately 30 gallons of water per day, or 900 gallons per month.[4] Installing a new flapper will pay for itself in avoided water and wastewater costs in one to two months.
Flushometer-valve toilets	Inspect diaphragm or piston valves for wear and tear. To determine if the valve needs replacement, see how long it takes to complete a flush cycle. A properly functioning 1.6 gpf flush valve should not have a flush cycle longer than four seconds. If replacing valve inserts, make sure the replacements are consistent with the valve manufacturer's specifications, including the rated flush volume. If replacing the entire valve, make sure it has a rated flush volume consistent with manufacturer specifications for the existing bowl.	Worn valves can result in more water than needed to flush the toilet. Also, flushometer valve bowls are specifically rated for a specific flush volume, and performance could be compromised with excess water.
Dual-flush toilets	Be sure to educate tenants in proper use of dual-flush toilets. Dual-flush toilets might be equipped with flush controls that could be confusing to some new or existing tenants. Include instructions in tenant welcome packets for proper operation of dual-flush toilets, and give periodic reminders if you have a property newsletter or other communications.	Dual-flush toilets can only achieve water savings if they're being used properly.

[1] U.S. Environmental Protection Agency (EPA) WaterSense. *WaterSense at Work. Best Management Practices for Commercial and Institutional Facilities*. October 2012. Page 2-9. www.epa.gov/sites/production/files/2017-02/documents/watersense-at-work_final_508c3.pdf
[2] New York City Department of Environmental Protection (NYC DEP). Repair Your Leaking Toilets: Save Water and Stop Flushing Away Your Water Bill. www.nyc.gov/html/dep/pdf/ways_to_save_water/toilet_brochure.pdf
[3] Estimated cost of water loss based on an average residential rate of $11.02 per 1,000 gallons for water and wastewater determined from data in: American Water Works Association (Raftelis Financial Consulting). 2016. Water and Wastewater Rate Survey.
[4] NYC DEP. *Op. Cit.*

Table 2. Bathroom Fixture Maintenance Tips for Periodic Inspections

Product Type	Tip	Why
Bathroom sink (lavatory faucets)	Conduct a visual inspection of faucet leaks. Train users to report continuously running, leaking, or otherwise malfunctioning faucets to the appropriate personnel.	A faucet that drips once per second can waste nearly 3,200 gallons[5] and more than $30 per year.[6]
Bathroom sink (lavatory faucets)	Scale accrual can occur when minerals build up on the aerator. Inspect faucet aerators for scale buildup to ensure flow is not restricted. Clean or replace the aerator or other spout end device if necessary.	Scale buildup can cause performance issues, resulting in occupants removing faucet aerators and increasing the faucet flow rate.
Bathroom sink (lavatory faucets)	Verify that faucet aerators rated at the intended flow rate are still installed on faucets found in unit bathrooms and public restrooms. WaterSense labeled faucet aerators for bathrooms within residential units have a flow rate of 1.5 gpm or less, whereas faucet aerators for public restrooms should have a flow rate of 0.5 gpm. If aerator removal is a common problem, consider installing tamper-proof aerators to prevent tenants from removing them.	When the flow of water is not controlled by a faucet aerator or laminar flow device, faucets can flow well over the federal standard of 2.2 gpm.
Showerheads	Inspect showerheads for scale buildup to ensure flow is not restricted. Use cleaning products that are designed to dissolve scale from showerheads with buildup. Do not attempt to bore holes in the showerhead or manually remove scale buildup, as this can lead to increased water use or cause performance problems. During your inspection of the showerhead, consider verifying the flow rate to ensure a tenant hasn't tampered with the showerhead to remove the flow restrictor.	Scale buildup can cause showerhead performance issues or an impeded flow, which reduces tenant comfort. Keeping water-efficient showerheads clean and performing well can help ensure tenant satisfaction.
Bath and shower diverters	Bath and shower diverters (also known as tub spout diverters or tub-shower diverters) divert the flow of water either toward a tub spout (i.e., to the bathtub) or toward a showerhead. Older diverters can leak due to worn parts or scale buildup. To check for a leaky diverter, turn on the shower and determine if water is flowing out of the diverter. If there is a leak, measure the diverter leak rate using a bucket and stopwatch. If the leak is greater than 0.1 gpm, replace the diverter. Fixing leaky diverters can save both water and energy, because the water leaking is typically hot water.	On average, old, leaky diverters can waste more than 1,500 gallons of water per year and as much as 4,200 gallons per year.[7]

[5] American Water Works Association. Drip Calculator: www.drinktap.org/water-info/water-conservation/drip-calculator.aspx
[6] Estimated cost of water loss based on an average residential rate of $11.02 per 1,000 gallons for water and wastewater determined from data in: American Water Works Association (Raftelis Financial Consulting). 2016. Water and Wastewater Rate Survey.
[7] U.S. EPA. *WaterSense Notice of Intent (NOI) to Develop a Draft Specification for Bath and Shower Diverters*. April 27, 2017.

Retrofit and Replacement Options

If installing a new fixture or replacing an older, inefficient product, consider installing a WaterSense labeled model or another water-efficient alternative. WaterSense labeled products are independently certified to meet EPA's efficiency and performance criteria, increases water savings, improves tenant satisfaction, and can help reduce maintenance issues.

- **Tank-type toilets:** WaterSense labeled tank-type toilets are independently certified to have an effective flush volume[8] of 1.28 gpf or less and pass a performance test to remove at least 350 grams or more of solid waste per flush.
- **Flushometer-valve toilets:** WaterSense labeled flushometer-valve toilets, whether single- or dual-flush, use no more than 1.28 gpf. They're also certified for performance to ensure they can handle typical commercial waste loads.
- **Bathroom sink (lavatory) faucets:** WaterSense labeled faucets and faucet accessories flow at 1.5 gpm or less at 60.0 pounds per square inch (psi) of water pressure and no less than 0.8 gpm at 20.0 psi. You can replace the entire faucet, or simply install a new faucet aerator instead.
- **Showerheads:** WaterSense labeled showerheads have a maximum flow rate of 2.0 gpm and are tested for spray force and coverage. Make sure your replacement fixtures flow through a thermostatic mixing valve to avoid the risk of thermal shock or scalding.

- **Bath and shower diverters:** Diverters are available on the market that effectively do not leak, eliminating water waste from tub spouts. If replacing bath and shower diverters, look for products tested to achieve a 0.00 gpm leak rate in pre-life cycle and post-life cycle testing.

You can identify WaterSense labeled models by using the WaterSense Product Search Tool and by looking for the WaterSense label on product packaging and websites. Be sure to check with your local water utility or use the WaterSense Rebate Finder to see if there are any rebates available in your area.

[8] For a single-flush toilet, the effective flush volume is the average flush volume when tested in accordance with national standard ASME A112.19.2. For a dual-flush toilet, the effective flush volume is defined as the average flush volume of two reduced flushes and one full flush, as determined by testing in accordance with national standards ASME A112.19.2 and ASME 112.19.14.

Water Savings Calculations and Assumptions

To estimate water (and energy) savings from replacing existing bathroom fixtures with more water-efficient models, review the calculations for each fixture type. The sources for assumptions included in the calculations are provided the Appendix.

Inputs

Occupancy: For efficiency projects where fixtures and fittings are being replaced, water savings in bathrooms (particularly those for multifamily properties) are largely based on unit occupancy rather than the number of fixtures. Even with multiple bathrooms within a unit, the water savings that can be achieved within the unit by replacing older plumbing fixtures will mostly remain the same.

Efficiency: For units where fixtures have different existing flush volumes/flow rates, average the existing flush volume/flow rates to establish the baseline water use.

Example:

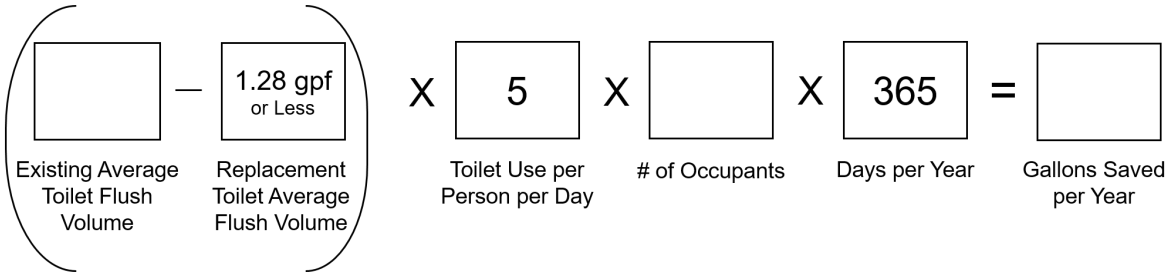
Let's say a unit has two bathrooms: one with a 3.5 gpf toilet and one with a 1.6 gpf toilet. To estimate water savings from replacing both existing toilets with 1.28 gpf or less WaterSense labeled models, use an existing average toilet flush volume of $\frac{(1.6\ \text{gpf}+3.5\ \text{gpf})}{2}$ = 2.55 gpf.

Alternatively, if only the 3.5 gpf toilet will be replaced, instead of including 1.28 gpf or less for the replacement toilet flush volume, use a replacement average toilet flush volume instead. In this example, the replacement average toilet flush volume for the unit would be $\frac{(1.6\ \text{gpf}+1.28\ \text{gpf})}{2}$ = 1.44 gpf because the 1.6-gpf toilet will remain. You can use a similar methodology for all bathroom fixtures.

Toilets

Replacing old toilets flushing at 1.6 gpf or more with WaterSense labeled models flushing at 1.28 gpf or less can result in significant water savings. To estimate potential water savings, use Equation 1.

Equation 1. Water Savings From Toilet Replacement (gallons per year)



If the flush volume of existing toilets is unknown, use Table 3 to estimate the existing flush volume based on the date of installation/initial construction.

Table 3. Assumptions for Toilet Water Savings Calculations

Existing Toilet Age	Existing Toilet Flush Volume
Installed from 1994 to Present	1.6 gpf
Installed between 1977 to 1994	3.5 gpf
Installed before 1977	5.0 gpf

Bathroom Sink Faucets

Replacing faucets or faucet aerators flowing at 2.0 gpm or more with WaterSense labeled models rated at 1.5 gpm or less can help reduce water use.

To estimate water savings from replacing faucets or faucet aerators, use Equation 2.

Equation 2. Water Savings From Bathroom Sink Faucet/Faucet Aerator Replacement (gallons per year)

0.6 gal	X		X	365	=	
Water Saved per Person per Day		# of Occupants		Days per Year		Gallons Saved per Year

Because lavatory faucets also use hot water, any resulting water savings can also save energy. Electricity savings (for electric water heaters) and natural gas savings (for natural gas water heaters) can be calculated using Equation 3a and 3b, respectively. If the efficiency of the hot water heater is unknown, consider using 100 percent efficiency for electric heaters and 75 percent for natural gas heaters to conservatively estimate energy savings.

Equation 3a. Electricity Savings From Bathroom Sink Faucet/Faucet Aerator Replacement (kilowatt hour [kWh] per year; for electric hot water heating)

	X	57%	X	0.183	÷		=	
Lavatory Faucet Gallons of Water Savings per Year		Percentage of Hot Water Used		kWh of Electricity Required to Heat One Gallon of Water		Water Heater Efficiency*		kWh Saved per Year

**Use 100% if exact electric heater efficiency is unknown*

Equation 3b. Natural Gas Savings From Bathroom Sink Faucet/Faucet Aerator Replacement (Thousand Cubic Feet [Mcf] per year; for natural gas hot water heating)

	X	57%	X	0.0061	÷		=	
Lavatory Faucet Gallons of Water Savings per Year		Percentage of Hot Water Used		Mcf of Natural Gas Required to Heat One Gallon of Water		Water Heater Efficiency*		Mcf Saved per Year

**Use 75% if exact natural gas heater efficiency is unknown*

Showerheads

To estimate water savings from replacing older, existing showerheads with WaterSense labeled models flowing at 2.0 gpm or less, use Equation 4.

Equation 4. Water Savings From Showerhead Replacement (gallons per year)

([ ] − [2.0 gpm or Less]) X [7.8] X [0.7] X [ ] X [365] = [ ]

Existing Average Showerhead Flow Rate	Replacement Average Showerhead Flow Rate	Minutes per Shower	Showers per Person per Day	# of Occupants	Days per Year	Gallons Saved per Year
	2.0 gpm or Less	7.8	0.7		365	

Because showerheads use hot water, any water savings will also result in energy savings. Electricity savings (for electric water heaters) and natural gas savings (for natural gas water heaters) can be calculated using Equation 5a and 5b, respectively. If the efficiency of the hot water heater is unknown, consider using 100 percent efficiency for electric heaters and 75 percent for natural gas heaters to conservatively estimate energy savings.

Equation 5a. Electricity Savings From Showerhead Replacement (kWh per year; for electric hot water heating)

([ ] X [66.2%] X [0.183]) ÷ [ ] = [ ]

Showerheads Gallons of Water Savings per Year	Percentage of Hot Water Used	kWh of Electricity Required to Heat One Gallon of Water	Water Heater Efficiency*	kWh Saved per Year
	66.2%	0.183		

**Use 100% if exact electric heater efficiency is unknown*

Equation 5b. Natural Gas Savings From Showerhead Replacement (Mcf per year; for natural gas hot water heating)

([ ] X [66.2%] X [0.0061]) ÷ [ ] = [ ]

Showerheads Gallons of Water Savings per Year	Percentage of Hot Water Used	Mcf of Natural Gas Required to Heat One Gallon of Water	Water Heater Efficiency*	Mcf Saved per Year
	66.2%	0.0061		

**Use 75% if exact natural gas heater efficiency is unknown*

Bath and Shower Diverters

Property managers should replace bath and shower diverters with a leak rate greater than 0.1 gpm with newer models that do not leak. You can determine the bath and shower diverter leak rate using a bucket or bag to manually collect water under the tub spout while the shower is running; measure the water collected in the bucket or bag over a one-minute period.

To estimate water savings from leaky bath and shower diverters, use Equation 6.

Equation 6. Water Savings from Fixing Diverter Leaks (gallons per year)

[ ]	X	7.8	X	0.7	X	[ ]	X	365	=	[ ]
Measured Diverter Leak Rate		Minutes per Shower		Showers per Person per Day		# of Occupants		Days per Year		Gallons Saved per Year

Because bath and shower diverters leak hot water, saving water will also save energy. To calculate electricity savings (for electric water heaters) and natural gas savings (for natural gas water heaters), substitute the Annual Diverter Water Savings with the Annual Showerhead Water Savings in Equations 5a and 5b on the previous page.

Additional Resources

Alliance for Water Efficiency Resource Library. Residential Water Use, Fixtures, and Appliances. www.allianceforwaterefficiency.org/Residential_Library_Content_Listing.aspx

Department of Energy (DOE) Office of Energy Efficiency & Renewable Energy (EERE) Federal Energy Management Program (FEMP). Best Management Practice #6: Toilets and Urinal. https://energy.gov/eere/femp/best-management-practice-6-toilets-and-urinals

DOE EERE FEMP. Best Management Practice #7: Faucets and Showerhead. https://energy.gov/eere/femp/best-management-practice-7-faucets-and-showerheads

EPA's WaterSense Program Resources:

Bath and Shower Diverters
www.epa.gov/watersense/bath-and-shower-diverters

Bathroom Faucets.
www.epa.gov/watersense/bathroom-faucets

Commercial Toilets.
www.epa.gov/watersense/commercial-toilets

Residential Toilets.
www.epa.gov/watersense/residential-toilets

Showerheads.
www.epa.gov/watersense/showerheads

WaterSense at Work. Best Management Practices for Commercial and Institutional Facilities.
www.epa.gov/watersense/best-management-practices

Appendix A: Summary of Water Efficiency Measures and Savings

This appendix can be used to summarize water efficiency measures, upgrades, and projects that are identified at your property, based on a water assessment and/or review of this Water Efficiency Management Guide.

Summary of Water Efficiency Measures and Savings

Item Number	Location	Measure or Project Name and Description	Projected Annual Water Savings (gallons)	Projected Annual Energy Savings	Projected Annual Water, Wastewater, and Energy Cost Savings ($)	Total Measure or Project Cost ($)	Simple Project Payback (years)
Example	*Second Floor (10 units)*	*Upgrade bathroom fixtures (toilets, showerheads, and faucets) in second floor units 201 through 210 with WaterSense labeled models. Each unit is 1.5 baths, so total project will require purchasing and installing 20 toilets, 20 faucets, and 10 showerheads. Estimated project cost is $530 per unit ($150 per toilet, $100 per faucet, $30 per showerhead).*	*105,000 gallons*	*3,200 kWh*	*Water & Wastewater Cost Savings: $1,150 Energy Cost Savings: $320* ***Total: $1,470***	*$5,300*	*3.6 years*
1							
2							
3							
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12							

Appendix B:References for Calculation Assumptions

Variable	Suggested Value	Units	Reference
Toilets			
Existing Average Toilet Flush Volume			
1994 to Present	1.6	gpf	Energy Policy Act (EPAct) 1992
1977 to 1994	3.5	gpf	North Carolina Department of Environment and Natural Resources (NC DENR), et al. May 2009. *Water Efficiency Manual for Commercial, Industrial and Institutional Facilities.* Page 28.
Pre-1977	5.0	gpf	NC DENR. *Op. Cit.*
Replacement Average Toilet Flush Volume	1.28 or less	gpf	EPA, 2014. *WaterSense Specification for Tank-Type Toilets.* Version 1.2. June 2, 2014; and EPA, 2015. *WaterSense Specification for Flushometer-Valve Water Closes.* Version 1.0. December 17, 2015.
Use Rate (Flushes per Occupant per Day)	5	flushes	Water Research Foundation (WRF). DeOreo, William B., Peter Mayer, Benedykt Dziegielewski and Jack Kiefer. *Residential End Uses of Water, Version 2.* 2016. Table 6.7, Page 115.
Days per Year	365	days	Constant
Bathroom Sink (Lavatory) Faucets			
Water Savings per Occupant per Day (from Replacing Standard 2.2 gpm Bathroom Sink Faucet with 1.5 gpm Faucet)	0.6	gallons	EPA, 2007. *WaterSense High-Efficiency Lavatory Faucet Specification Supporting Statement.* Version 1.0. October 1, 2007.
Days per Year	365	days	Constant
Percentage of Faucet Water Used That Is Hot Water	57.0	%	WRF. *Op. Cit.* Table 6.25, Page 138.
kWh of Electricity Required to Heat One Gallon of Water 75°F	0.183	kWh/gallon	WaterSense calculation assuming: • Specific heat of water = 1.0 Btu/lb x °F • 1 gallon of water = 8.34 lbs • 1 kWh = 3,412 Btus • Incoming water temperature is raised 75°F
Electric Hot Water Heater Efficiency	Building/Unit Specific (use 100% efficiency if unknown)		U.S. Department of Energy (2014) *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers*. Office of Energy Efficiency and Renewable Energy (EERE), Building Technologies Program, Appliances and Commercial Equipment Standards, p. 7-1

Variable	Suggested Value	Units	Reference
Mcf of Natural Gas Required to Heat One Gallon of Water 75°F	0.00061	Mcf/gallon	WaterSense calculation assuming: • Specific heat of water = 1.0 Btu/lb x °F • 1 gallon of water = 8.34 lbs • 1 Therm = 99,976 Btus • 1 Mcf of natural gas = 10.307 therms • Incoming water temperature is raised 75°F
Natural Gas Hot Water Heater Efficiency	Building/Unit Specific (use 75% efficiency if unknown)		U.S. Department of Energy (2014). *Op. Cit.*
Showerheads and Diverters			
Existing Average Showerhead Flow Rate	2.5	gallons per minute (gpm)	EPAct 1992
Replacement Average Showerhead Flow Rate	2.0 or less	gpm	EPA, 2010. *WaterSense Specification for Showerheads.* Version 1.0. March 4, 2010.
Average Shower Duration	7.8	minutes	WRF. *Op. Cit.* Table 6.9, Page 120.
Use Rate (Showers per Occupant per Day)	0.7	showers per person per day	WRF. *Op. Cit.* Table 6.9, Page 120.
Days per Year	365	days	Constant
Percentage of Showerhead Water Used That Is Hot Water	66.2	%	WRF. *Op. Cit.* Table 6.25, Page 138.
kWh of Electricity Required to Heat One Gallon of Water 75°F	0.183	kWh/gallon	WaterSense calculation assuming: • Specific heat of water = 1.0 Btu/lb x °F • 1 gallon of water = 8.34 lbs • 1 kWh = 3,412 Btus • Incoming water temperature is raised 75°F
Electric Hot Water Heater Efficiency	Building/Unit Specific (use 100% efficiency if unknown)		U.S. Department of Energy (2014). *Op. Cit.*
Mcf of Natural Gas Required to Heat One Gallon of Water 75°F	0.00061	Mcf/gallon	WaterSense calculation assuming: • Specific heat of water = 1.0 Btu/lb x °F • 1 gallon of water = 8.34 lbs • 1 Therm = 99,976 Btus • 1 Mcf of natural gas = 10.307 therms • Incoming water temperature is raised 75°F
Natural Gas Hot Water Heater Efficiency	Building/Unit Specific (use 75% efficiency if unknown)		U.S. Department of Energy (2014). *Op. Cit.*