Everything High Performance Builders Need to Know About (Hot) Water

2024 EEBA Summit

Salt Lake City

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Learning Objectives

1. Explain why time-to-tap and volume-until-hot are goals set during the schematic design process.
2. Discuss the benefits of architectural compactness.
3. Appreciate the decisions that need to be made to minimize pressure loss in the building's water distribution system.
4. Specify pressure independent flow regulators for faucets and showerheads.
5. Understand the best ways to integrate air-source heat pump water heaters into a high-performance home.
6. Incorporate right-sizing into the plumbing design process via the IAPMO Water Demand Calculator.

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How Long Should We Wait?

Volume in the Pipe (ounces)	Minimum Time-to-Tap (seconds) at Selected Flow Rates					
	0.25 gpm	0.5 gpm	1 gpm	1.5 gpm	2 gpm	2.5 gpm
~~2~~ 1	4	1.9	0.9	0.6	0.5	0.4
~~4~~ 2	8	4	1.9	1.3	0.9	0.8
~~8~~ 4	15	8	4	2.5	1.9	1.5
~~16~~ 8	30	15	8	5	4	3
~~24~~ 12	45	23	11	8	6	5
~~32~~ 16	60	30	15	10	8	6
~~64~~ 32	120	60	30	20	15	12
~~128~~ 64	240	120	60	40	30	24

Cut the pipe volume in half to get these times

ASPE Time-to-Tap Performance Criteria

	Acceptable Performance	1 – 10 seconds
	Marginal Performance	11 – 30 seconds
	Unacceptable Performance	31+ seconds

Source: Domestic Water Heating Design Manual – 2nd Edition, ASPE, 2003, page 234

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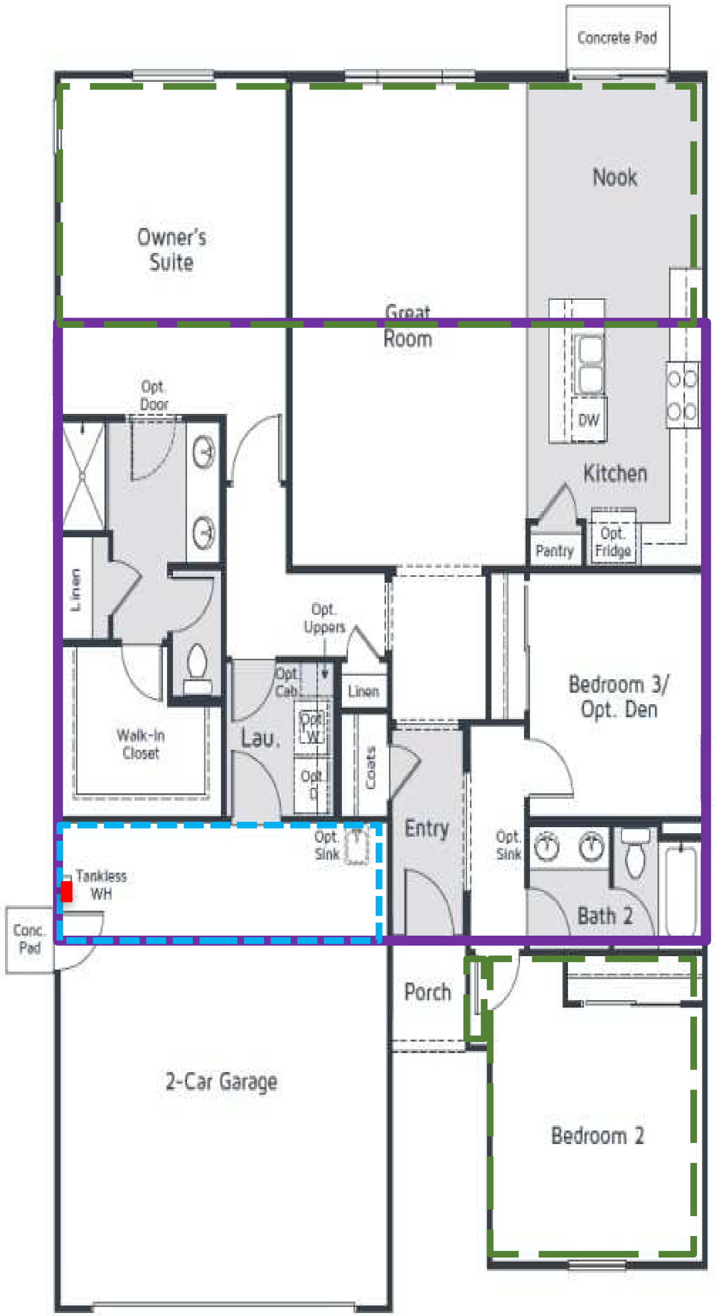
Distance Between the Wet Rooms and the Water Heater

Example:

1 Story
3Br/2Ba
1,697 sq ft
Fresno, CA
~67% (1137 sq ft)



Relationship between the Hot Water System and the Floor Area – The Logical Worst Case

Number of Stories	Hot Water System/ Floor Area (%)
1-story	100%
2-story	50%
3-story	33.3%
4-story	25%
5-story	20%

Many buildings are worse than this!

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Where Does All the Pressure Go?

Let's Look at a 2nd Floor Shower

	PSI	PSI		
Street Pressure	60	80		
Go up 20 feet	- 9	- 9		
Tub/Shower Valve	- 11	- 11		
Losses in the piping		- 20	- 20	
Total of the Pressure Losses			- 40	- 40
Residual Pressure at the shower head			20	40

Showerhead flow rates are determined at 80 psi.

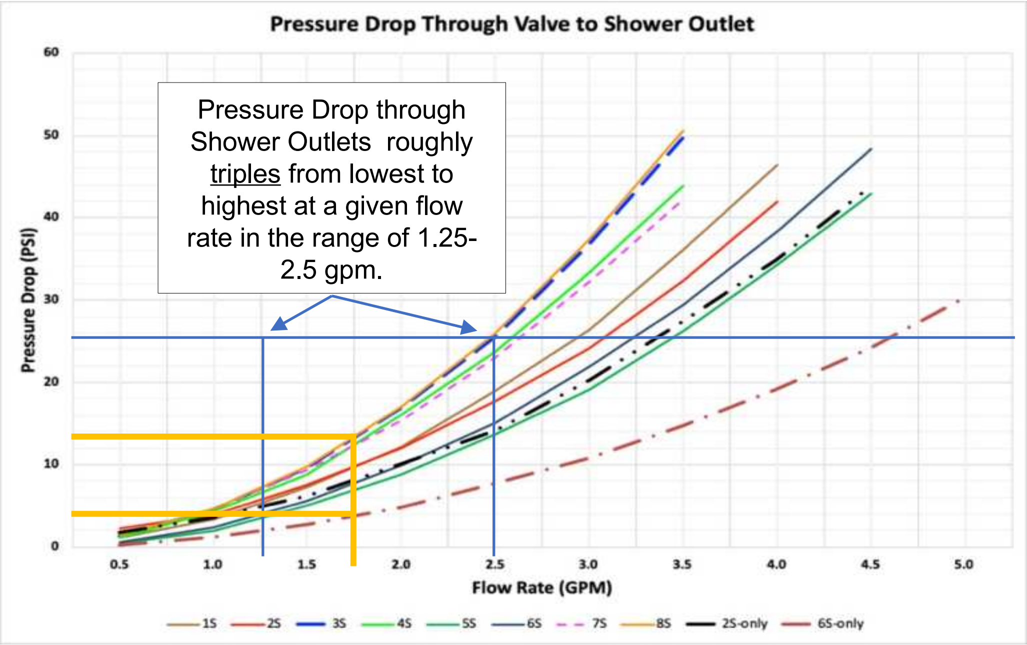
For fixed orifice showerheads, the flow rate will be much less

Flow rate at 40 psi = 0.7 * Flow Rated at 80 psi

Flow rate at 20 psi = 0.49 * Flow Rated at 80 psi

Similar reductions for faucets with flow rated at 60 psi

	Pressure Loss Per Fitting @ 3 gpm		
1/2 Inch Nominal	Copper	CPVC	PEX
PSI per Fitting	0.05	0.2	0-2
		4 times copper	Up to 40 times copper
3/8 Inch Nominal	Copper	CPVC	PEX
PSI per Fitting	0.2-0.4	NA	0-12
			Up to 30-60 times copper



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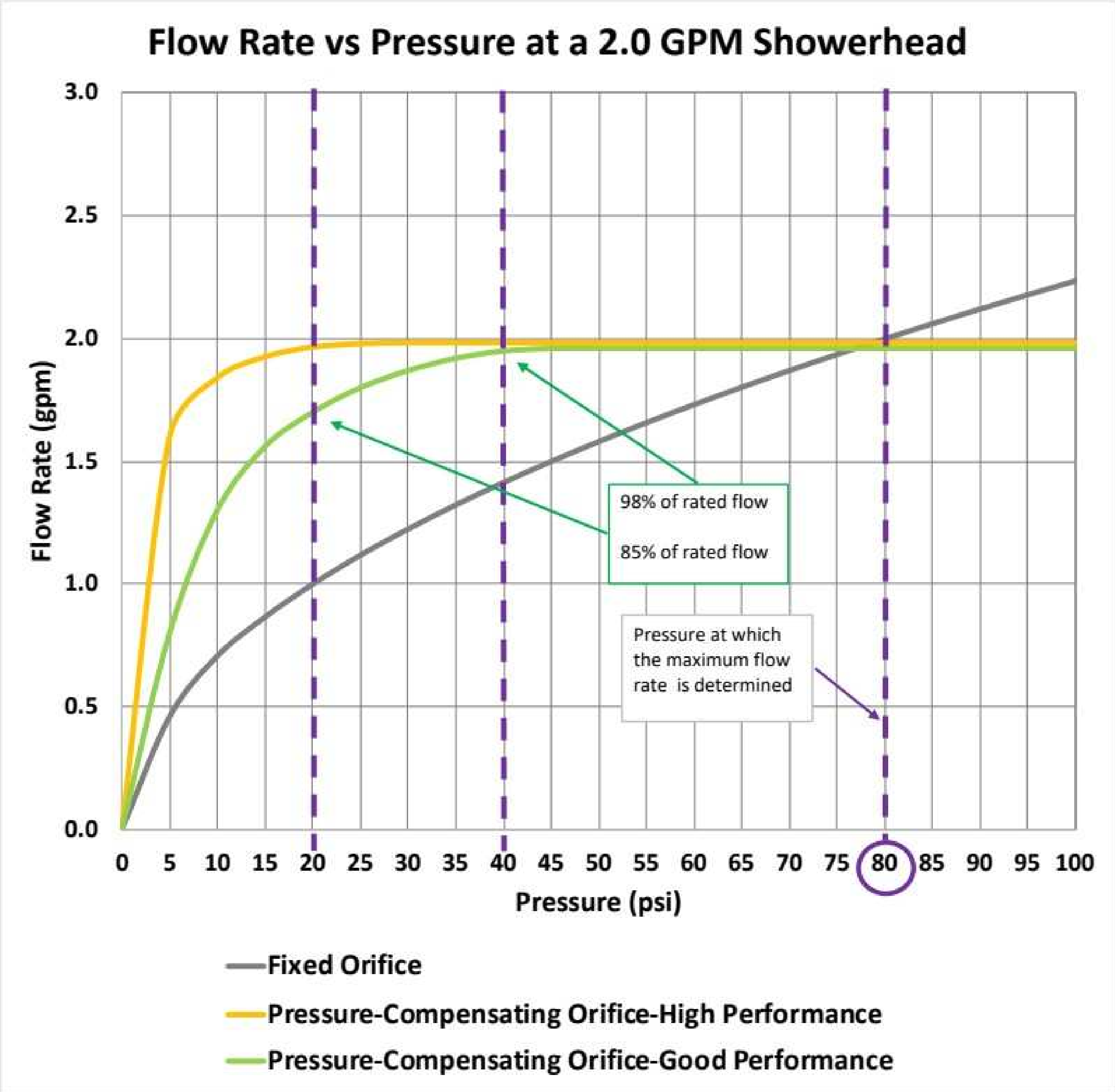
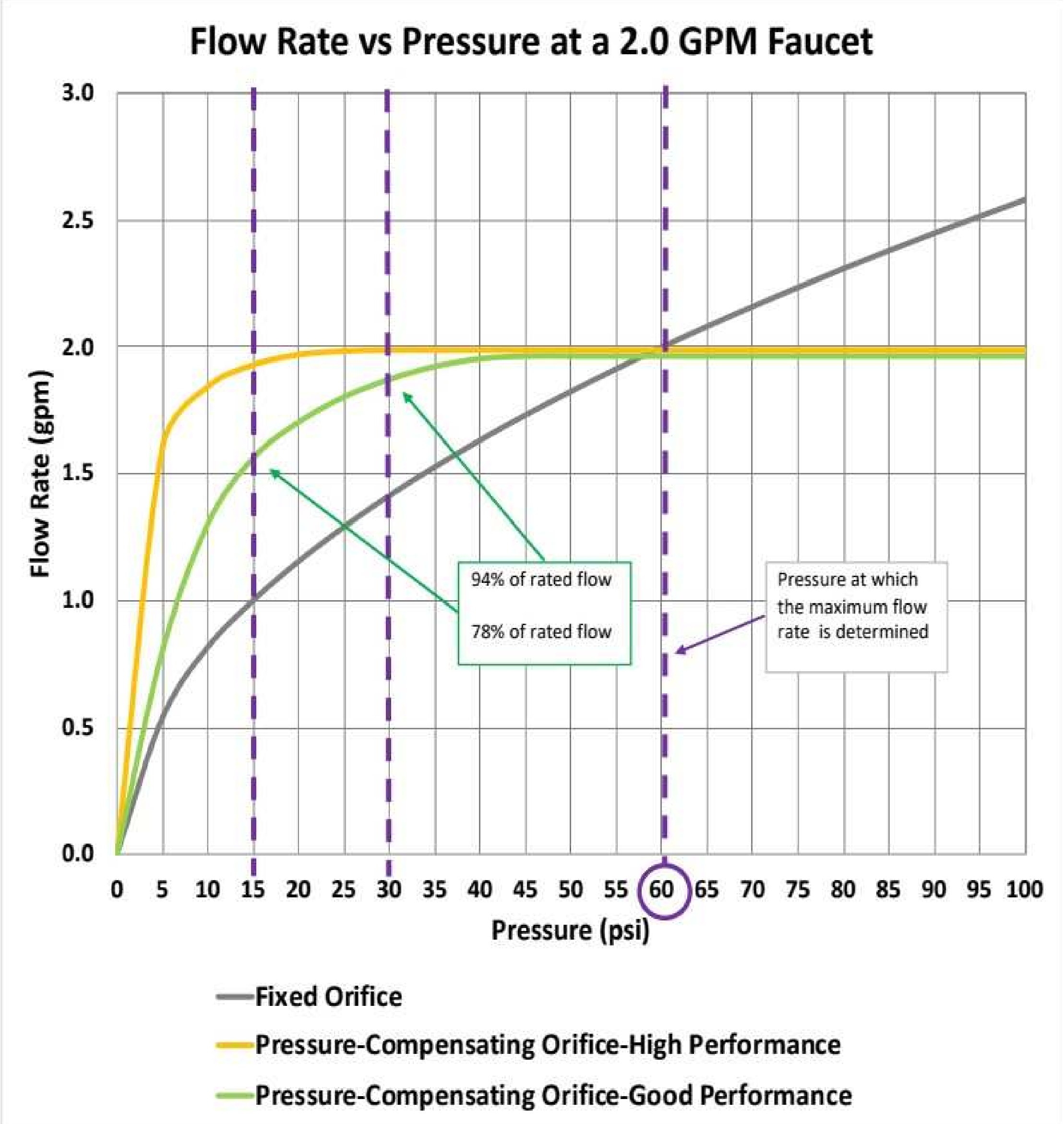


Which one do you want?



Select Good or High-Performance Faucet Aerators to Increase Customer Satisfaction.

Flow Rate (GPM)

0.375

0.5

1.0

1.2

1.5

1.75

2.2

Which one do you want?

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Heat Pump Water Heaters – The Essentials

- Thermal resource for the supply
- Thermal sink for the discharge
- For air source HPWH, the key is air flow, not room volume.
- Critical to manage the discharge of the cold air
  - Dew point, condensation, mold
  - Occupant comfort
  - Unintended interactions with the building thermostat

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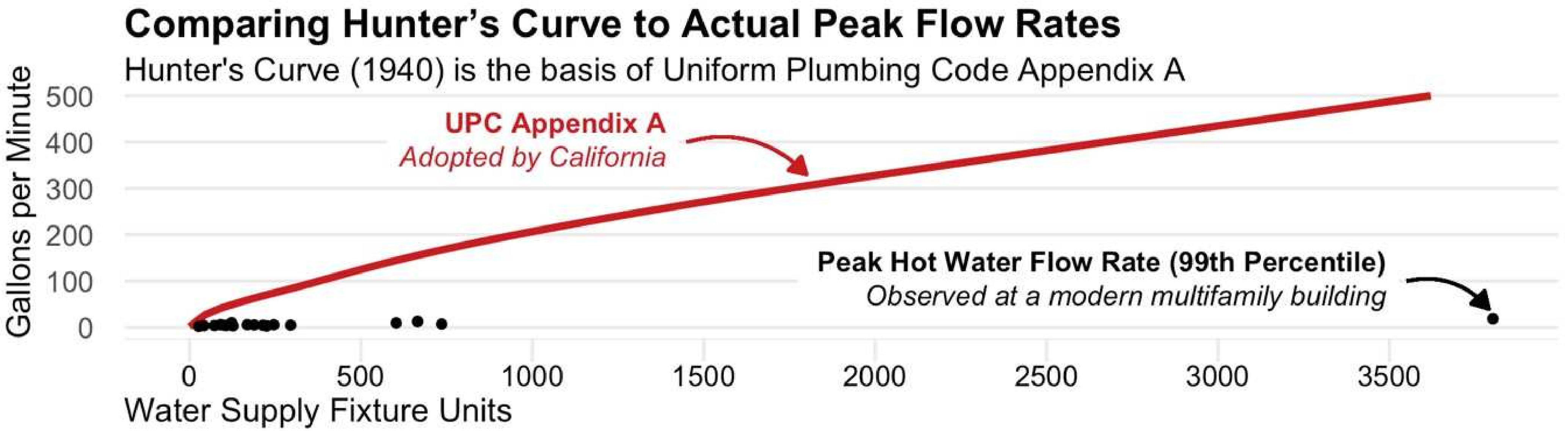

Comparing Hunter's Curve to Actual Peak Flow Rates
Hunter's Curve (1940) is the basis of Uniform Plumbing Code Appendix A
Gallons per Minute
500
400
300
200
100
0
UPC Appendix A
Adopted by California
Peak Hot Water Flow Rate (99th Percentile)
Observed at a modern multifamily building
0
500
1000
1500
2000
2500
3000
3500
Water Supply Fixture Units

Comparing Hunter's Curve to Actual Peak Flow Rates

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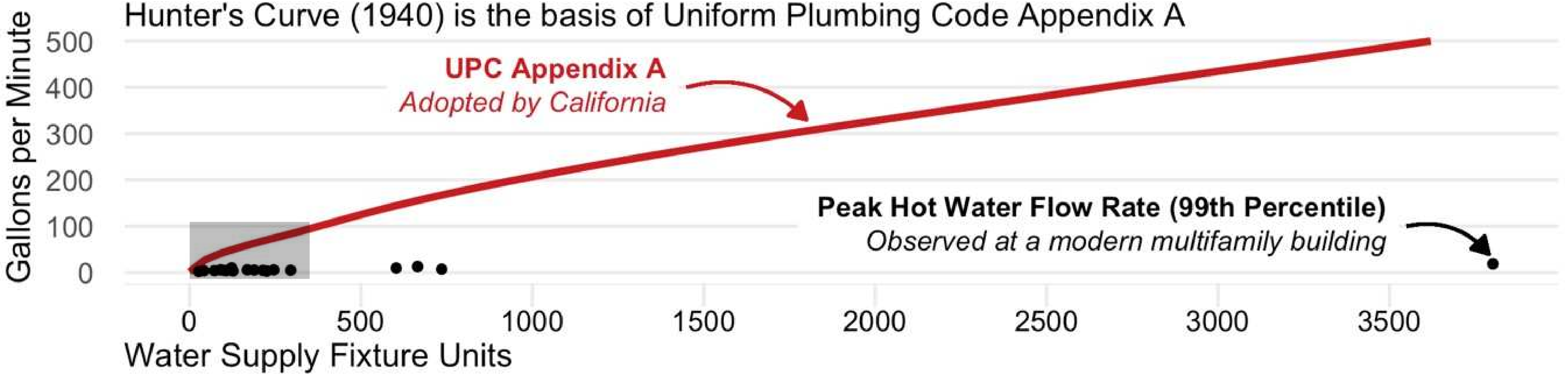
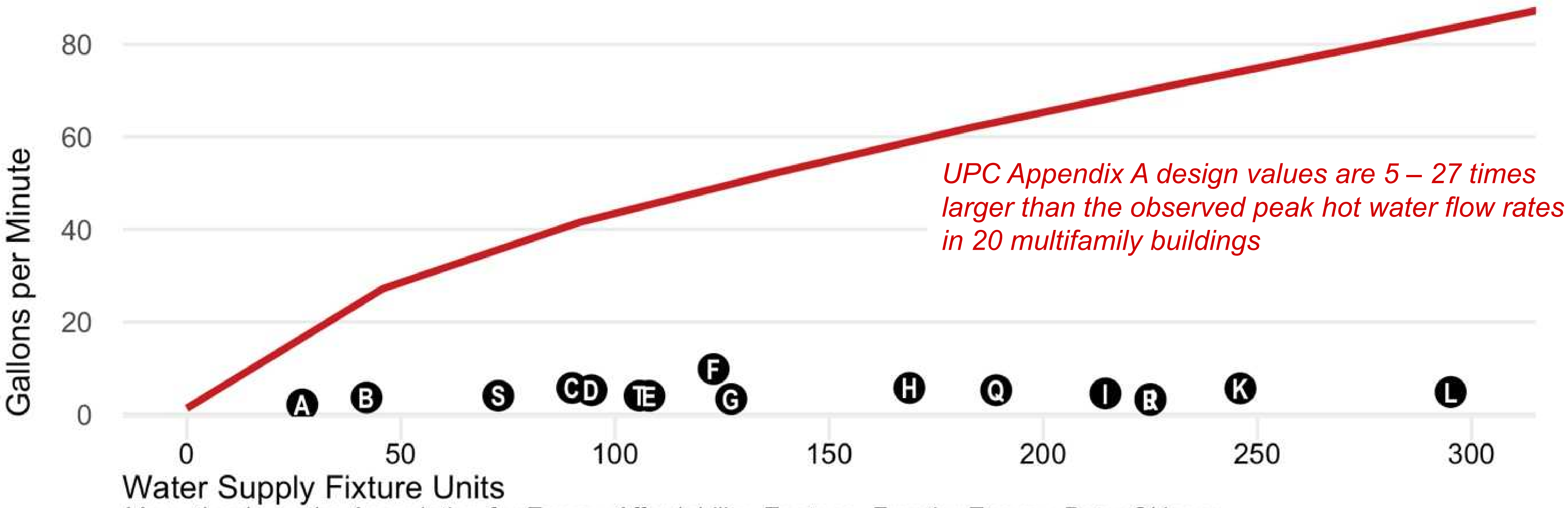




Many thanks to the Association for Energy Affordability, Ecotope, Frontier Energy, Peter Skinner, and the UC Davis Western Cooling Efficiency Center for providing data.

2022 California Plumbing Code, Chapter 6 Water Supply and Distribution, Section 610.5

610.5 Sizing per Appendices A, C, *and M*. Except as provided in Section 610.4, the size of each water piping system shall be determined in accordance with the procedure set forth in Appendix A. For *alternative* methods of sizing water supply systems, see Appendix C *or Appendix M*.

2022 California Plumbing Code, Appendix M Peak Water Demand Calculator

M 101.0 General.

M 101.1 Applicability. This appendix provides *an alternative* method for estimating the demand load for the building water supply and principal branches for single- and multi-family dwellings with water-conserving plumbing fixtures, fixture fittings, and appliances.

M 102.0 Demand Load.

M 102.1 Water-Conserving Fixtures. Plumbing fixtures, fixture fittings, and appliances shall not exceed the design flow rate in Table M 102.1.

TABLE M 102.1
DESIGN FLOW RATE FOR WATER-CONSERVING PLUMBING FIXTURES AND APPLIANCES IN RESIDENTIAL OCCUPANCIES

FIXTURE AND APPLIANCE	MAXIMUM DESIGN FLOW RATE (gallons per minute)
Bar Sink	1.5
Bathtub	5.5
Bidet	2.0
Clothes Washer	3.5
Combination Bath/Shower	5.5
Dishwasher	1.3
Kitchen Faucet	*1.8*
Laundry Faucet (with aerator)	2.0
Lavatory Faucet	*1.2*
Shower, per head	*1.8*
Water Closet, 1.28 GPF Gravity Tank	3.0

For SI units: 1 gallon per minute = 0.06 L/s

The Water Demand Calculator has been adopted in more than 10 jurisdictions in the US and Canada.

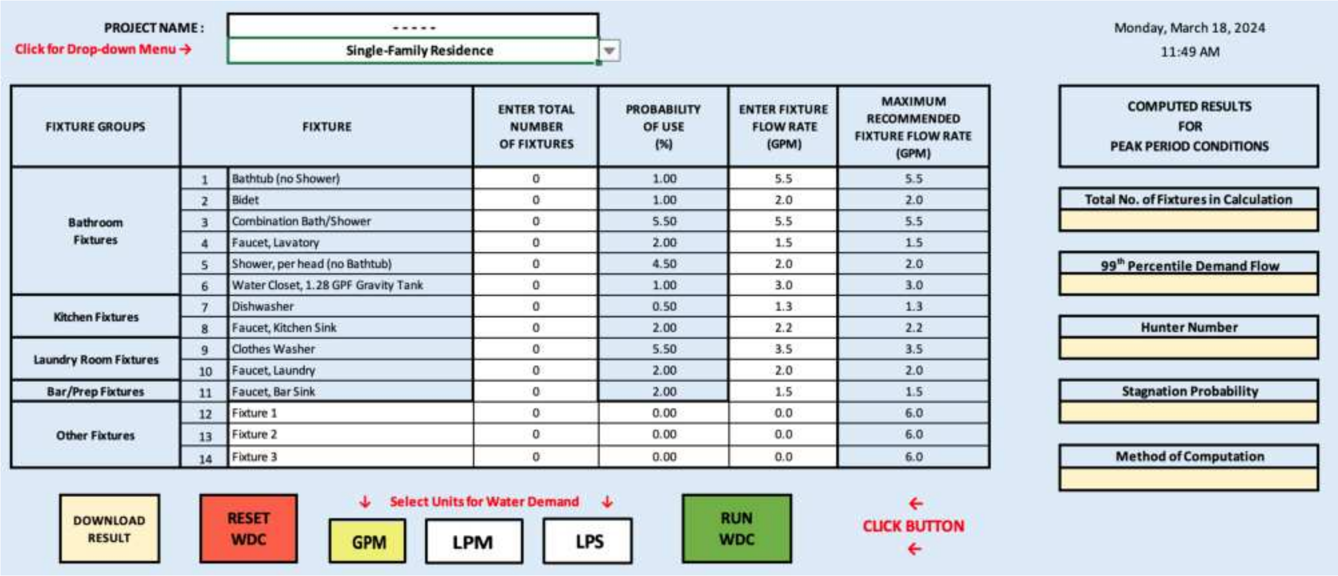
And can be utilized in IPC and IRC-P jurisdictions.

It applies to residential new construction and can justify the use of existing premise plumbing for renovation or adaptive reuse projects.

Sources:
2022 CPC with 7/1/2024 Supplement, Chapter 6, Section 610.5 https://epubs.iapmo.org/2022/CPC/#p=202
2022 CPC with 7/1/2024 Supplement, Appendix M Peak Water Demand Calculator https://epubs.iapmo.org/2022/CPC/#p=550

The Water Demand Calculator (version 2.2)

Single Family



PROJECT NAME : -----

Click for Drop-down Menu → Single-Family Residence

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FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	0	5.50	5.5	5.5
	4	Faucet, Lavatory	0	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	0	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

COMPUTED RESULTS FOR PEAK PERIOD CONDITIONS

Total No. of Fixtures in Calculation

99th Percentile Demand Flow

Hunter Number

Stagnation Probability

Method of Computation

DOWNLOAD RESULT

RESET WDC

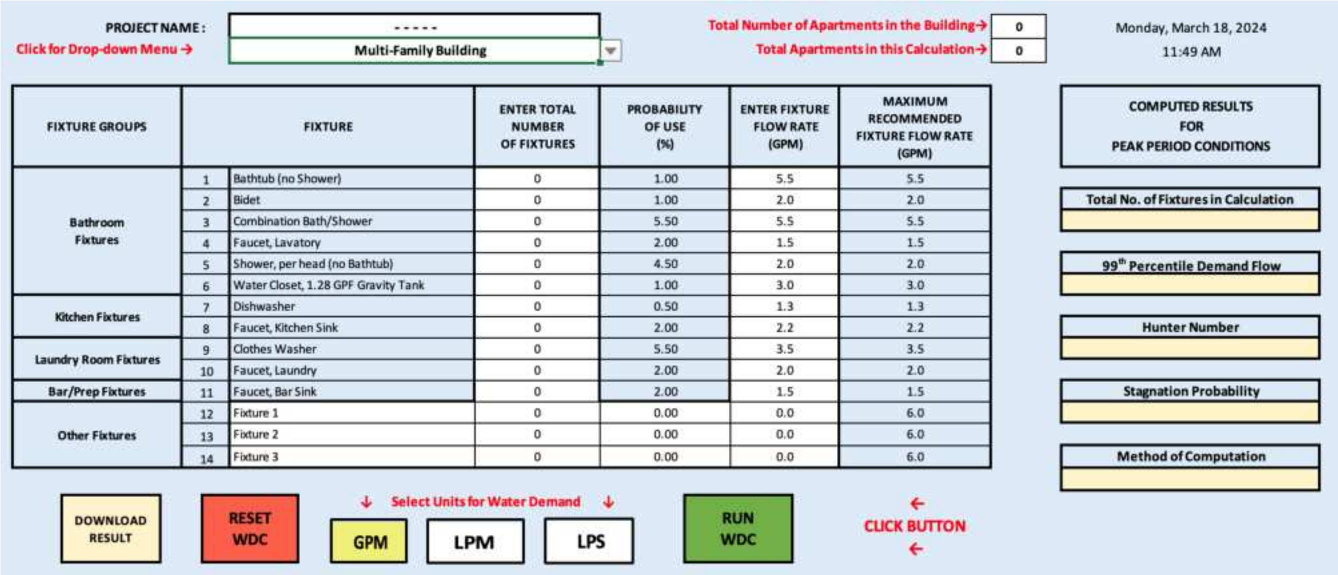
Select Units for Water Demand

GPM LPM LPS

RUN WDC

CLICK BUTTON

Multi-Family



PROJECT NAME : -----

Click for Drop-down Menu → Multi-Family Building

Total Number of Apartments in the Building → 0

Total Apartments in this Calculation → 0

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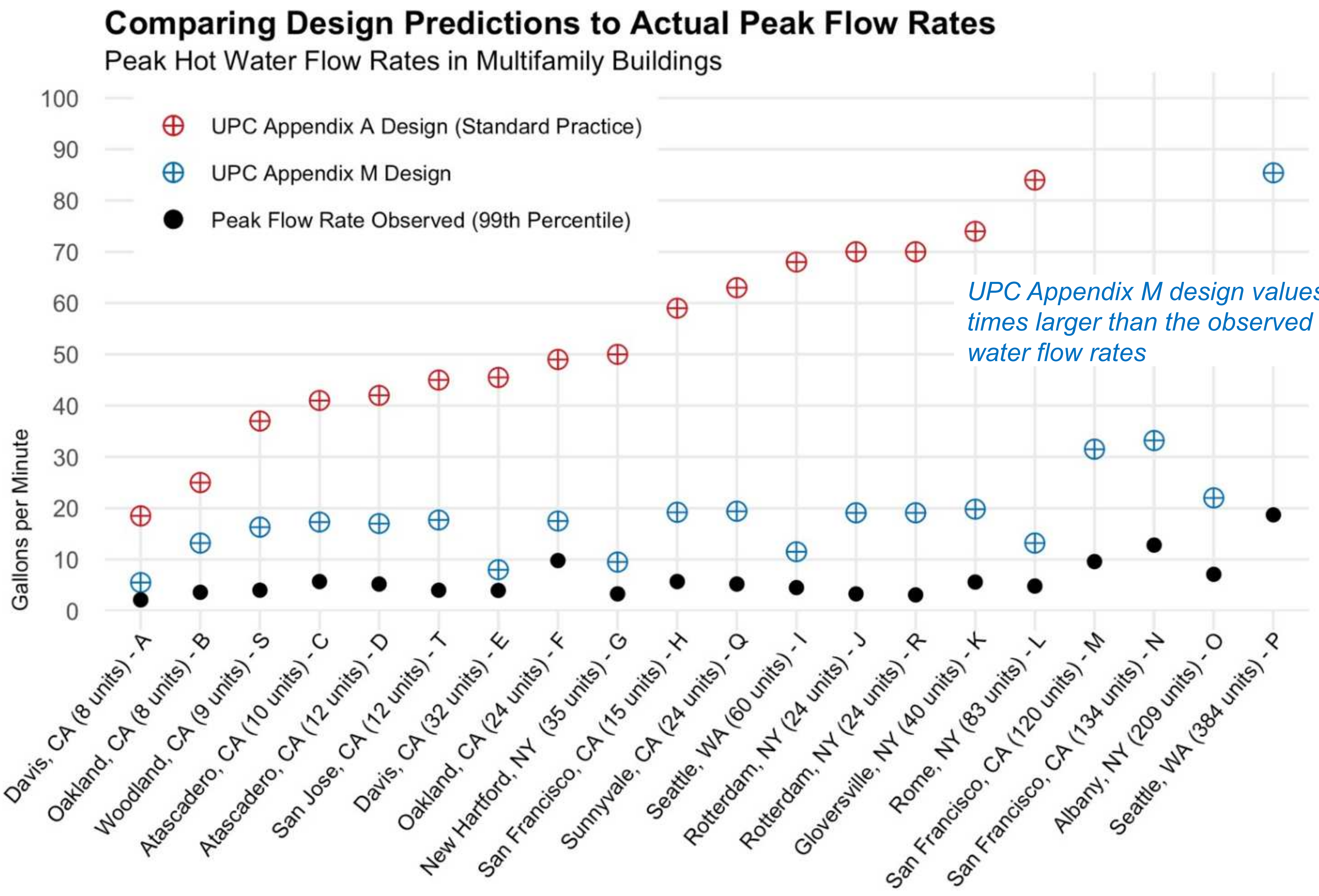
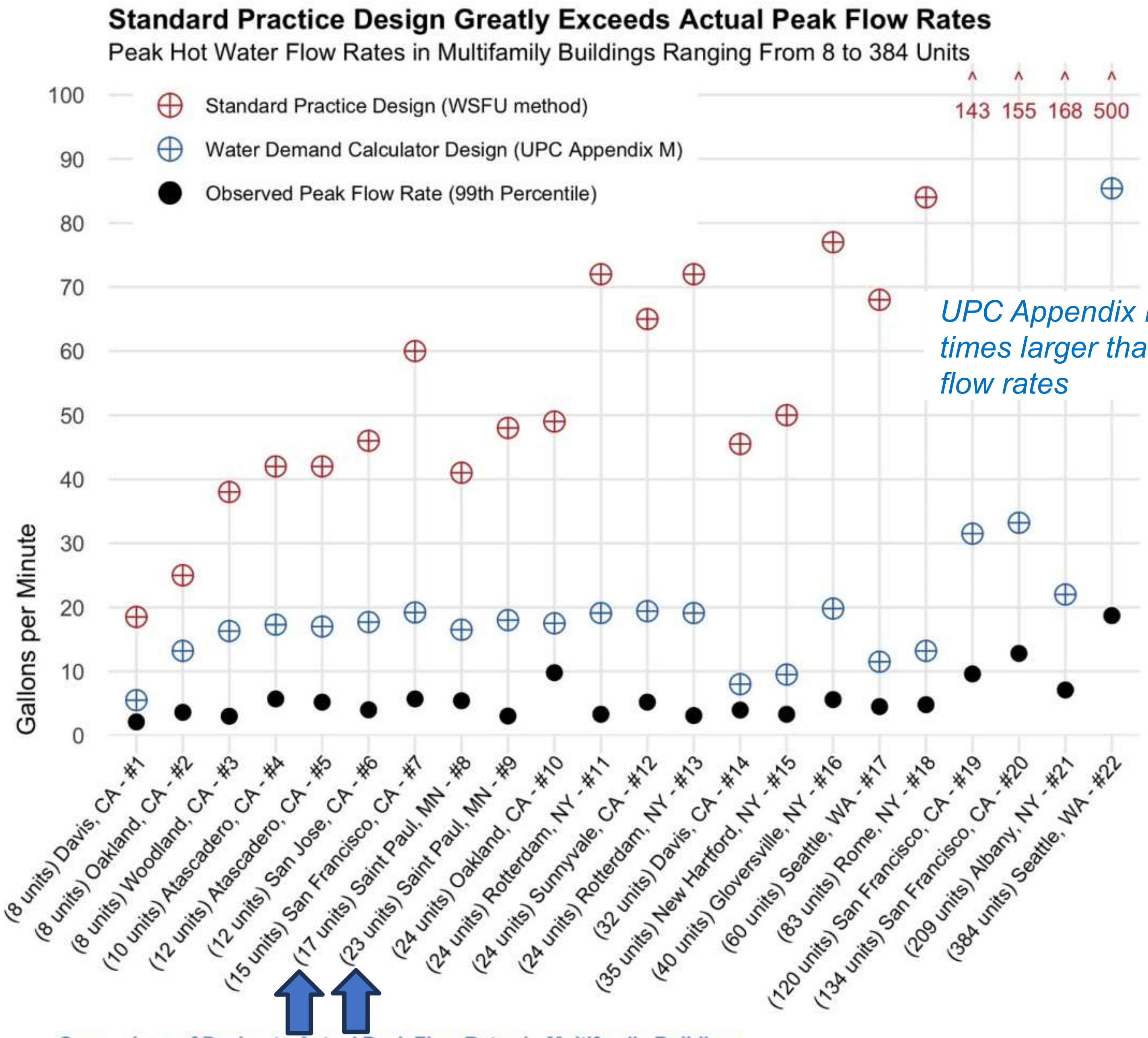
CLICK BUTTON

https://www.iapmo.org/we-stand/water-demand-calculator/water-demand-calculator-california/



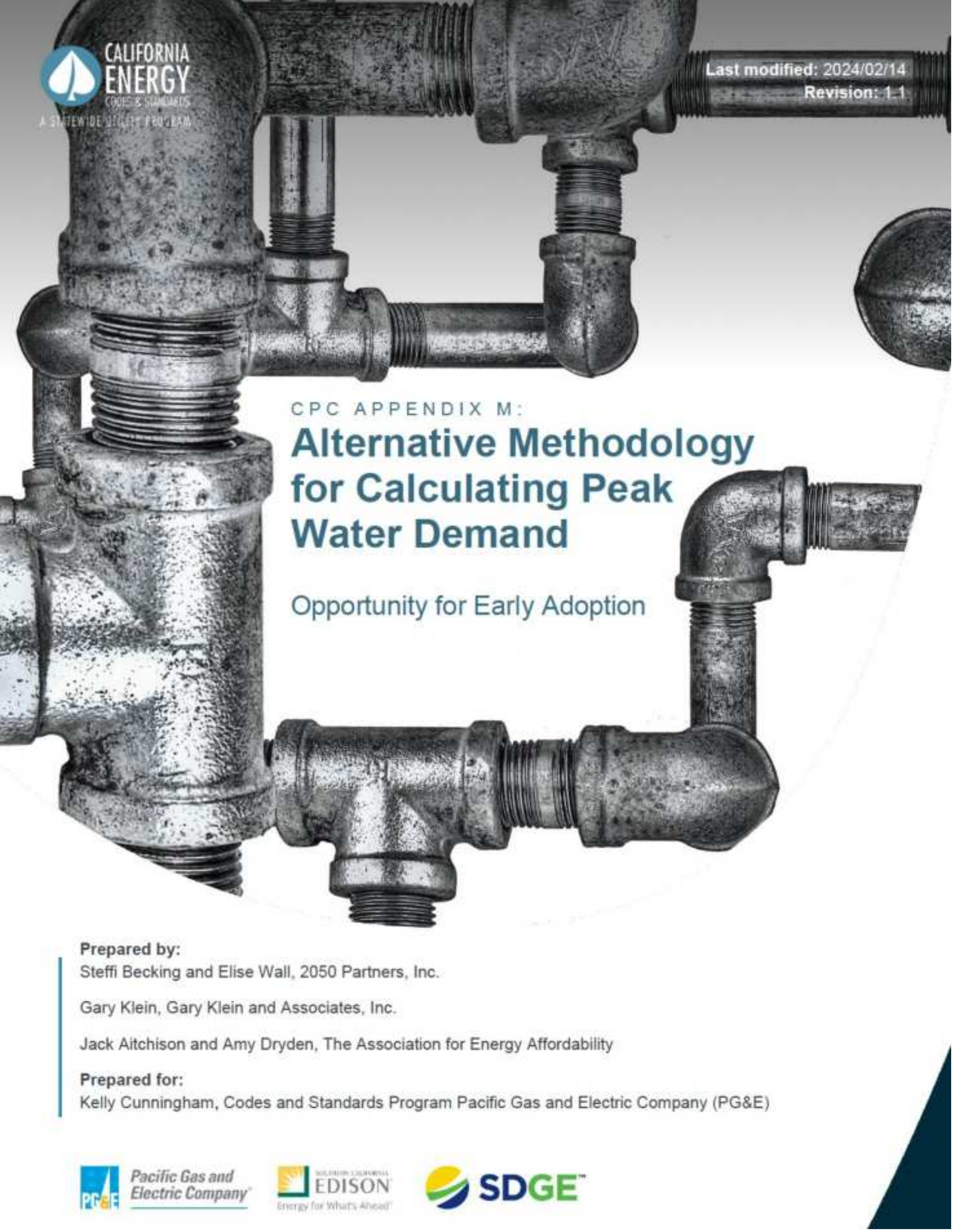
UPC Appendix M design values are 2 – 6 times larger than the observed peak hot water flow rates

Many thanks to the Association for Energy Affordability, Ecotope, Frontier Energy, Peter Skinner, and the UC Davis Western Cooling Efficiency Center for providing data.



UPC Appendix M design values are 2 – 6 times larger than the observed peak hot water flow rates

Comparison of Design to Actual Peak Flow Rates in Multifamily Buildings.


Last modified: 2024/02/14
Revision: 1.1

CPC APPENDIX M:

Alternative Methodology for Calculating Peak Water Demand

Opportunity for Early Adoption

Prepared by:
Steffi Becking and Elise Wall, 2050 Partners, Inc.

Gary Klein, Gary Klein and Associates, Inc.

Jack Aitchison and Amy Dryden, The Association for Energy Affordability

Prepared for:
Kelly Cunningham, Codes and Standards Program Pacific Gas and Electric Company (PG&E)

Pacific Gas and Electric Company EDISON SDGE

For more information, see the report summarizing the analysis that compared design predictions to actual data for hot water flow rates in 20 multifamily buildings.

Source:
https://localenergycodes.com/content/reach-codes/energy-plus-water-1 (to access the report, click "VIEW AND DOWNLOAD RESOURCES" for the "require alternative method for sizing water pipes in residential buildings" measure)
https://localenergycodes.com/download/1461/file_path/fieldList/2024%20CPC%20Appx%20M-Alternative%20Calc%20Water%20Demand.pdf (direct download link)

Thank you!

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