

# Right Sizing Pipe Based on Modern Materials and Flow Rates

## Plumbing Efficiency Workshop:

Forecasting code changes where  
water meets energy

Fort Collins, Colorado  
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# City of Fort Collins Building and Plumbing Code: Effective January 12, 2019

## Maximum Flow Rates and Water Consumption for Plumbing Fixtures

All fixtures listed below must be Environmental Protection Agency (EPA) WaterSense®-labeled fixtures, excluding fixtures and fittings that are not labeled under the WaterSense program.

International Plumbing Code (Commercial)		International Residential Code	
Lavatory faucet, private	1.5 gpm – I and R Occupancies (e.g. hospitals, assisted living facilities, multi-family, hotels, dormitories) <b>0.5 gpm – all other occupancies</b>	Lavatory faucet	1.5 gpm at 60 psi
Lavatory, faucet public (metering)	0.25 gpm		
Lavatory faucet, public (other than metering)	0.5 gpm		
Showerhead	2.0 gpm - I and E occupancies (e.g. hospitals, assisted living facilities, K-12 schools, education facilities) <b>1.8 gpm – all other occupancies</b>	Showerhead	<b>1.8 gpm</b> at 80 psi
Sink faucet	1.8 gpm	Sink faucet	1.8 gpm at 60 psi
Urinal	0.5 gpf		
Water closet	1.28 gpf and min <b>600 MaP®</b>	Water closet	1.28 gpf AND minimum MaP® of <b>600 grams</b>
Bar sinks (food service)	2.2 gpm		
Pre-rinse spray valve	1.28 gpm		

gpm: gallons per minute      gpf: gallons per flush

# Let's Start with a Typical Dwelling

	<b>Total</b>	<b>Hot</b>	<b>Cold</b>
	<b>GPM</b>	<b>GPM</b>	<b>GPM</b>
<b>Master Bathroom</b>			
2 Lavatory sinks	1.5	1.5	1.5
1 Shower	1.8	1.25	1.25
1 Stand alone tub	5.0	5.0	5.0
1 Toilet, 1.28 gpf	3.0	0	3.0
<b>Bath 2</b>			
1 Lavatory sink	1.5	1.5	1.5
1 Tub/Shower Combo			
Tub	4.0	2.8	2.8
Shower	1.8	1.25	1.25
1 Toilet, 1.28 gpf	3.0	0	3.0
<b>Kitchen</b>			
1 Kitchen sink	1.8	1.8	1.8
1 Dishwasher	1.5	1.5	0
<b>Laundry Room</b>			
1 Washing Machine	3.5	3.5	3.5

# Pipe Sizing Methods

## Which one(s) do you use?

1. International Code Council
  1. International Residential Code (IRC)
  2. International Plumbing Code (IPC)
  3. Local adoption as amended?
2. International Association of Plumbing and Mechanical Officials (IAPMO)
  1. Uniform Plumbing Code (UPC)
  2. Location adoption as amended?
3. American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE)
4. American Society of Plumbing Engineers (ASPE)
5. Others?

# Pipe Sizing – 2018 IRC

TABLE AP103.3(2)  
LOAD VALUES ASSIGNED TO FIXTURES\*

FIXTURE	OCCUPANCY	TYPE OF SUPPLY CONTROL	LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (w.s.f.u.)		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flushometer valve	6.0	3.0	8.0
Bathtub	Private	Faucet	1.0	1.0	1.4
Bathtub	Public	Faucet	3.0	3.0	4.0
Bidet	Private	Faucet	1.5	1.5	2.0
Combination fixture	Private	Faucet	2.25	2.25	3.0
Dishwashing machine	Private	Automatic	—	1.4	1.4
Drinking fountain	Offices, etc.	$\frac{1}{8}$ " valve	0.25	—	0.25
Kitchen sink	Private	Faucet	1.0	1.0	1.4
Kitchen sink	Hotel, restaurant	Faucet	3.0	3.0	4.0
Laundry trays (1 to 3)	Private	Faucet	1.0	1.0	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2.0
Service sink	Offices, etc.	Faucet	2.25	2.25	3.0
Shower head	Public	Mixing valve	3.0	3.0	4.0
Shower head	Private	Mixing valve	1.0	1.0	1.4
Urinal	Public	1" flushometer valve	10.0	—	10.0
Urinal	Public	$\frac{3}{4}$ " flushometer valve	5.0	—	5.0
Urinal	Public	Flush tank	3.0	—	3.0
Washing machine (8 lb)	Private	Automatic	1.0	1.0	1.4
Washing machine (8 lb)	Public	Automatic	2.25	2.25	3.0
Washing machine (15 lb)	Public	Automatic	3.0	3.0	4.0
Water closet	Private	Flushometer valve	6.0	—	6.0
Water closet	Private	Flush tank	2.2	—	2.2
Water closet	Public	Flushometer valve	10.0	—	10.0
Water closet	Public	Flush tank	5.0	—	5.0
Water closet	Public or private	Flushometer tank	2.0	—	2.0

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

- a. For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads, and for total load. The separate hot and cold water loads are three-fourths of the total load for the fixture in each case.

**BATHROOM GROUP.** A group of fixtures consisting of a water closet, lavatory, bathtub or shower, including or excluding a bidet, an *emergency floor drain* or both. Such fixtures are located together on the same floor level.

# Pipe Sizing – 2018 IRC

	<b>Total</b>	<b>Hot</b>	<b>Cold</b>
	<b><u>wsfu</u></b>	<b><u>wsfu</u></b>	<b><u>wsfu</u></b>
<b>Master Bathroom</b>			
2 Lavatory sinks	1.4	1.0	1.0
1 Shower	1.4	1.0	1.0
1 Stand alone tub	1.4	1.0	1.0
1 Toilet, 1.28 gpf	2.2	0	2.2
<b>Bath 2</b>			
1 Bathroom group	3.6	1.5	2.7
<i>1 Lavatory sink</i>	<i>0.7</i>	<i>0.5</i>	<i>0.5</i>
<i>1 Tub/Shower Combo</i>	<i>3.0</i>	<i>2.25</i>	<i>2.25</i>
<i>1 Toilet, 1.28 gpf</i>	<i>2.2</i>	<i>0</i>	<i>2.2</i>
<b>Kitchen</b>			
1 Kitchen sink	1.4	1.0	1.0
1 Dishwasher	1.4	1.4	0
<b>Laundry Room</b>			
1 Washing Machine	<u>1.4</u>	<u>1.0</u>	<u>1.0</u>
	<b>14.2</b>	<b>7.9</b>	<b>9.9</b>

# Pipe Sizing – 2018 IRC

**Total:** 14.2 wsfu / 17.1 gpm    **Hot:** 7.9 wsfu / 12.7 gpm    **Cold:** 9.9 wsfu / 14.5 gpm

**TABLE AP103.3(3)  
TABLE FOR ESTIMATING DEMAND**

SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS			SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETERS		
Load	Demand		Load	Demand	
(w.s.f.u.)	(gpm)	(cfm)	(w.s.f.u.)	(gpm)	(cfm)
1	3.0	0.04104	—	—	—
2	5.0	0.0684	—	—	—
3	6.5	0.86892	—	—	—
4	8.0	1.06944	—	—	—
5	9.4	1.256592	5	15.0	2.0052
6	10.7	1.430376	6	17.4	2.326032
7	11.8	1.577424	7	19.8	2.646364
8	12.8	1.711104	8	22.2	2.967696
9	13.7	1.831416	9	24.6	3.288528
10	14.6	1.951728	10	27.0	3.60936
11	15.4	2.058672	11	27.8	3.716304
12	16.0	2.13888	12	28.6	3.823248
13	16.5	2.20572	13	29.4	3.930192
14	17.0	2.27256	14	30.2	4.037136
15	17.5	2.3394	15	31.0	4.14408
16	18.0	2.90624	16	31.8	4.241024
17	18.4	2.459712	17	32.6	4.357968
18	18.8	2.513184	18	33.4	4.464912

# Pipe Sizing – 2018 IRC

Total: 17.1 gpm

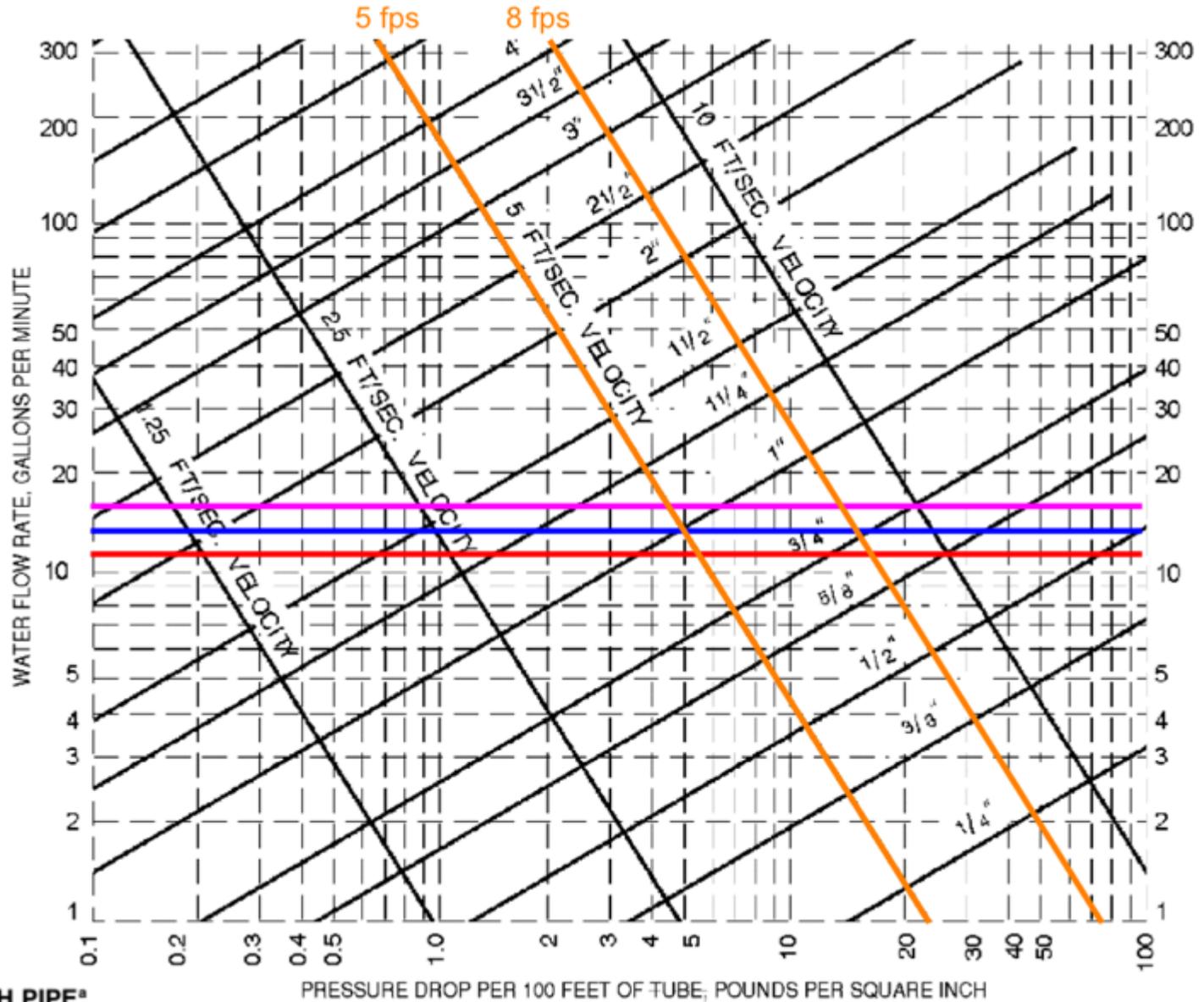
- 1"

Hot: 12.7 gpm

- 3/4"

Cold: 14.5 gpm

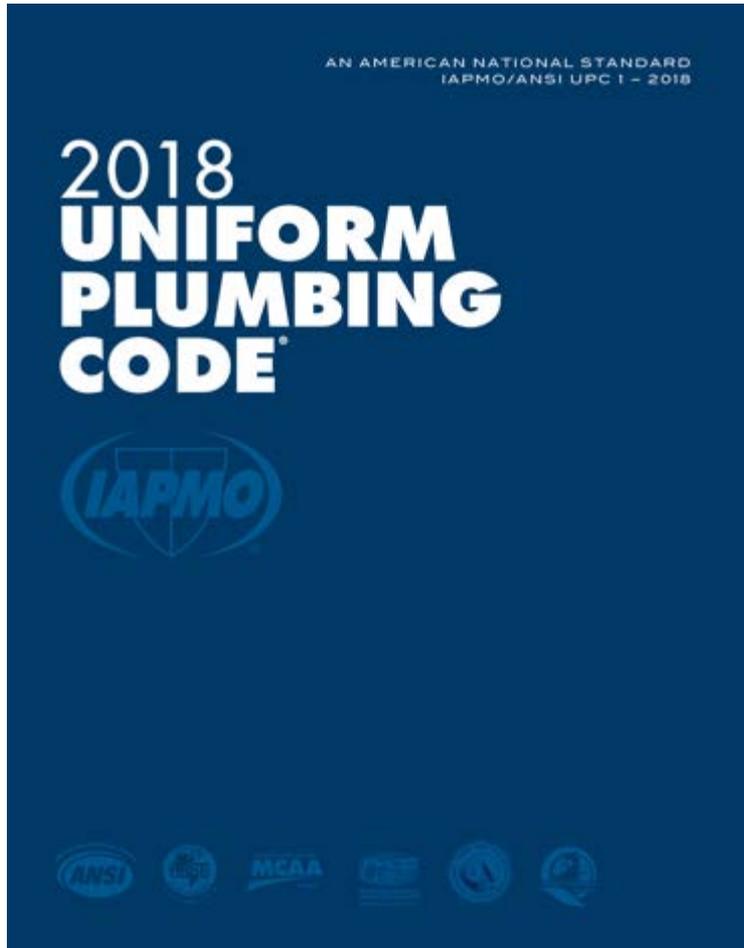
- 3/4"



FRICITION LOSS IN SMOOTH PIPE<sup>a</sup>  
(TYPE L, ASTM B88 COPPER TUBING)

# Pipe Sizing for Peak Flows

## Standard Method



## Appendix M: Water Demand Calculator

Tuesday, July 24, 2018 11:04 PM ↓ Select Units ↓

PROJECT NAME :

FIXTURE GROUPS	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1 Bathtub (no Shower)	0	1.0	5.5	5.5
	2 Bidet	0	1.0	2.0	2.0
	3 Combination Bath/Shower	0	5.5	5.5	5.5
	4 Faucet, Lavatory	0	2.0	1.5	1.5
	5 Shower, per head (no Bathtub)	0	4.5	2.0	2.0
	6 Water Closet, 1.28 GPF Gravity Tank	0	1.0	3.0	3.0
Kitchen Fixtures	7 Dishwasher	0	0.5	1.3	1.3
	8 Faucet, Kitchen Sink	0	2.0	2.2	2.2
Laundry Room Fixtures	9 Clothes Washer	0	5.5	3.5	3.5
	10 Faucet, Laundry	0	2.0	2.0	2.0
Bar/Prep Fixtures	11 Faucet, Bar Sink	0	2.0	1.5	1.5
Other Fixtures	12 Fixture 1	0	0.0	0.0	6.0
	13 Fixture 2	0	0.0	0.0	6.0
	14 Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures      0

99<sup>th</sup> PERCENTILE DEMAND FLOW =  GPM

↑ CLICK BUTTON ↑

<http://www.iapmo.org/Pages/WaterDemandCalculator.aspx>

# Appendix M

1. Provides a method to estimate 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
2. The method used in the Peak Water Demand Calculator is based on probabilities of simultaneous use from residential water use surveys and actual fixture flow rates
3. A useful tool for “right-sizing” pipe.

# Pipe Sizing – Appendix M

Version 1.4 (March 2019)

↓ Select Units ↓

Friday, February 28, 2020 8:47 AM

PROJECT NAME :

TOTAL (HOT + COLD)

GPM

LPM

LPS

FIXTURE GROUPS	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
<b>Bathroom Fixtures</b>	1 Bathtub (no Shower)	1	1.0	5.0	5.5
	2 Bidet	0	1.0	2.0	2.0
	3 Combination Bath/Shower	1	5.5	4.0	5.5
	4 Faucet, Lavatory	3	2.0	1.5	1.5
	5 Shower, per head (no Bathtub)	1	4.5	1.8	2.0
	6 Water Closet, 1.28 GPF Gravity Tank	2	1.0	3.0	3.0
<b>Kitchen Fixtures</b>	7 Dishwasher	1	0.5	1.3	1.3
	8 Faucet, Kitchen Sink	1	2.0	1.8	2.2
<b>Laundry Room Fixtures</b>	9 Clothes Washer	1	5.5	3.5	3.5
	10 Faucet, Laundry	0	2.0	2.0	2.0
<b>Bar/Prep Fixtures</b>	11 Faucet, Bar Sink	0	2.0	1.5	1.5
<b>Other Fixtures</b>	12 Fixture 1	0	0.0	0.0	6.0
	13 Fixture 2	0	0.0	0.0	6.0
	14 Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures 11

99<sup>th</sup> PERCENTILE DEMAND FLOW = 7.5 GPM

RESET

RUN WATER  
DEMAND  
CALCULATOR

# Pipe Sizing – Appendix M

Version 1.4 (March 2019)

↓ Select Units ↓

Friday, February 28, 2020 8:51 AM

PROJECT NAME :

**HOT**

GPM

LPM

LPS

FIXTURE GROUPS	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
<b>Bathroom Fixtures</b>	1 Bathtub (no Shower)	1	1.0	5.0	5.5
	2 Bidet	0	1.0	2.0	2.0
	3 Combination Bath/Shower	1	5.5	2.8	5.5
	4 Faucet, Lavatory	3	2.0	1.5	1.5
	5 Shower, per head (no Bathtub)	1	4.5	1.3	2.0
	6 Water Closet, 1.28 GPF Gravity Tank	0	1.0	3.0	3.0
<b>Kitchen Fixtures</b>	7 Dishwasher	1	0.5	1.3	1.3
	8 Faucet, Kitchen Sink	1	2.0	1.8	2.2
<b>Laundry Room Fixtures</b>	9 Clothes Washer	1	5.5	3.5	3.5
	10 Faucet, Laundry	0	2.0	2.0	2.0
<b>Bar/Prep Fixtures</b>	11 Faucet, Bar Sink	0	2.0	1.5	1.5
<b>Other Fixtures</b>	12 Fixture 1	0	0.0	0.0	6.0
	13 Fixture 2	0	0.0	0.0	6.0
	14 Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures

9

99<sup>th</sup> PERCENTILE DEMAND FLOW = 6.5 GPM

RESET

RUN WATER  
DEMAND  
CALCULATOR

# Pipe Sizing – Appendix M

Version 1.4 (March 2019)

↓ Select Units ↓

Friday, February 28, 2020 2:47 PM

PROJECT NAME :

COLD

GPM

LPM

LPS

FIXTURE GROUPS	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
<b>Bathroom Fixtures</b>	1 Bathtub (no Shower)	1	1.0	5.0	5.5
	2 Bidet	0	1.0	2.0	2.0
	3 Combination Bath/Shower	1	5.5	2.8	5.5
	4 Faucet, Lavatory	3	2.0	1.5	1.5
	5 Shower, per head (no Bathtub)	1	4.5	1.3	2.0
	6 Water Closet, 1.28 GPF Gravity Tank	2	1.0	3.0	3.0
<b>Kitchen Fixtures</b>	7 Dishwasher	0	0.5	1.3	1.3
	8 Faucet, Kitchen Sink	1	2.0	1.8	2.2
<b>Laundry Room Fixtures</b>	9 Clothes Washer	1	5.5	3.5	3.5
	10 Faucet, Laundry	0	2.0	2.0	2.0
<b>Bar/Prep Fixtures</b>	11 Faucet, Bar Sink	0	2.0	1.5	1.5
<b>Other Fixtures</b>	12 Fixture 1	0	0.0	0.0	6.0
	13 Fixture 2	0	0.0	0.0	6.0
	14 Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures 10

99<sup>th</sup> PERCENTILE DEMAND FLOW = 6.5 GPM

RESET

RUN WATER  
DEMAND  
CALCULATOR

# Pipe Sizing – Appendix M

Total: 7.5 gpm

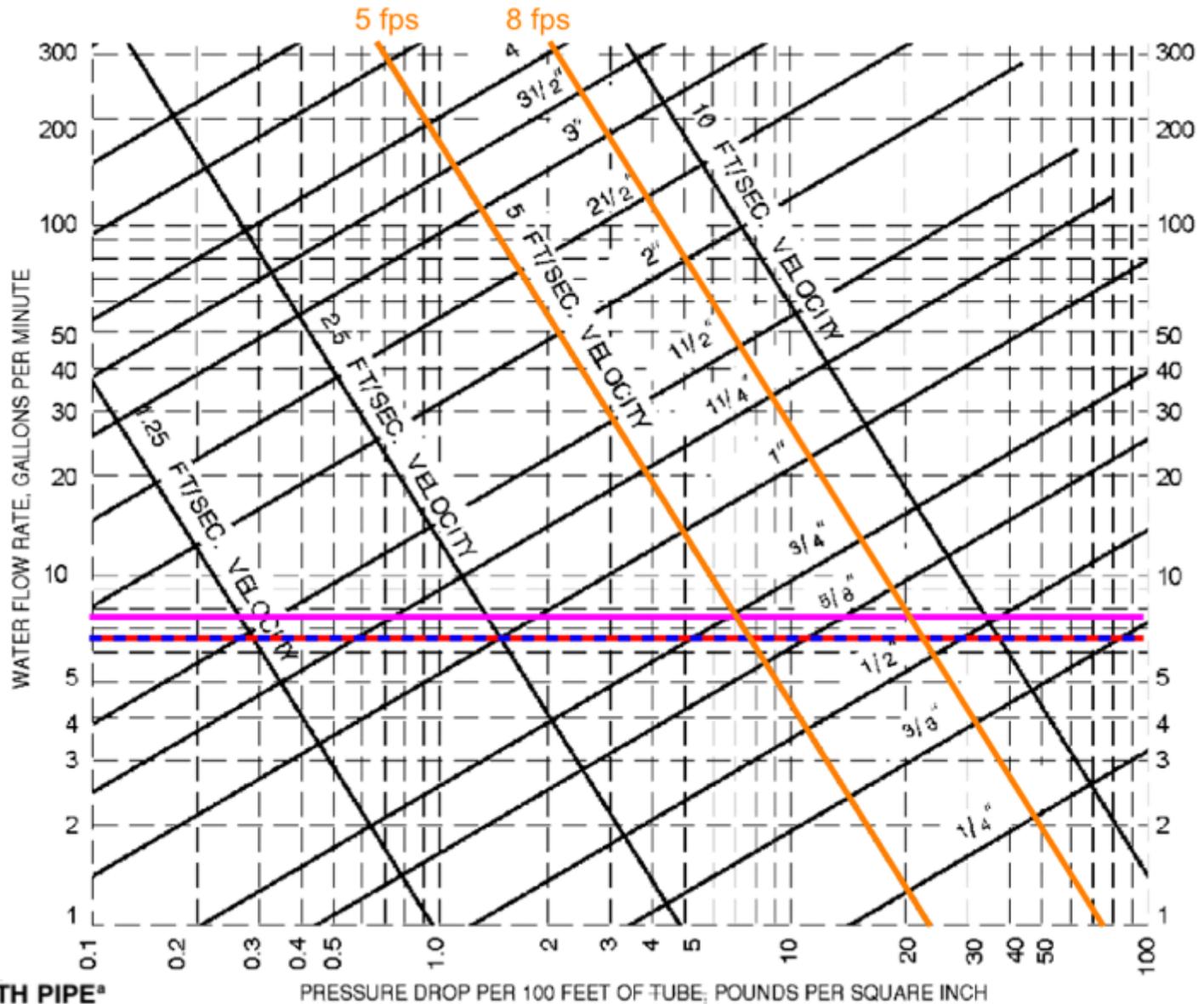
- 3/4"

Hot: 6.5 gpm

- 1/2"

Cold: 6.5 gpm

- 1/2"



FRICITION LOSS IN SMOOTH PIPE\*  
(TYPE L, ASTM B88 COPPER TUBING)

# Pipe Sizing – Appendix M

Total: 7.5 gpm

- 3/4"

Hot: 6.5 gpm

- 3/4"

Cold: 6.5 gpm

- 3/4"

Nomograph from UPC  
Appendix I (PEX)

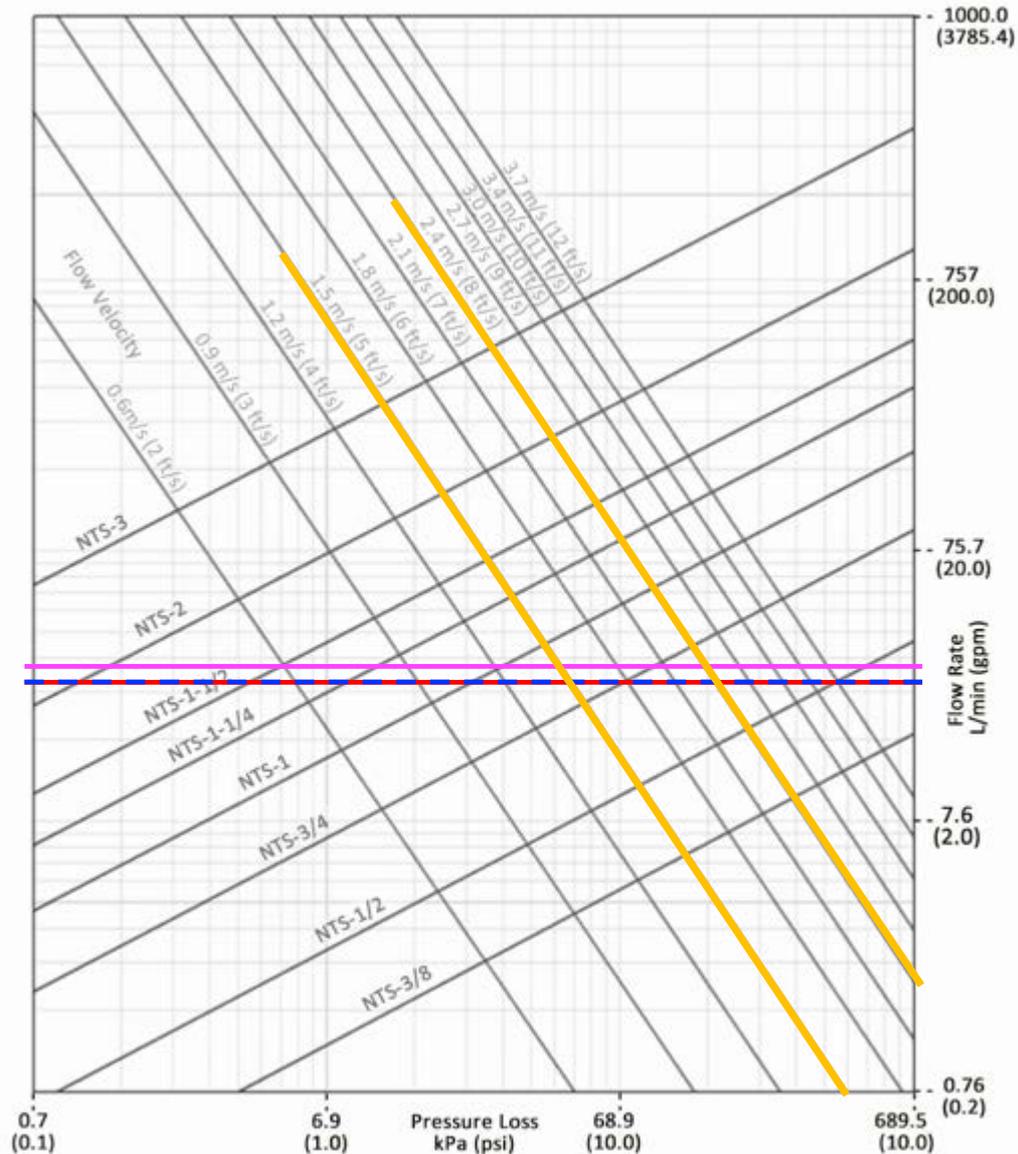


FIGURE 3  
PRESSURE LOSS OF PEX TUBING AT 16 °C (60 °F)  
(See Section 10.6.2)

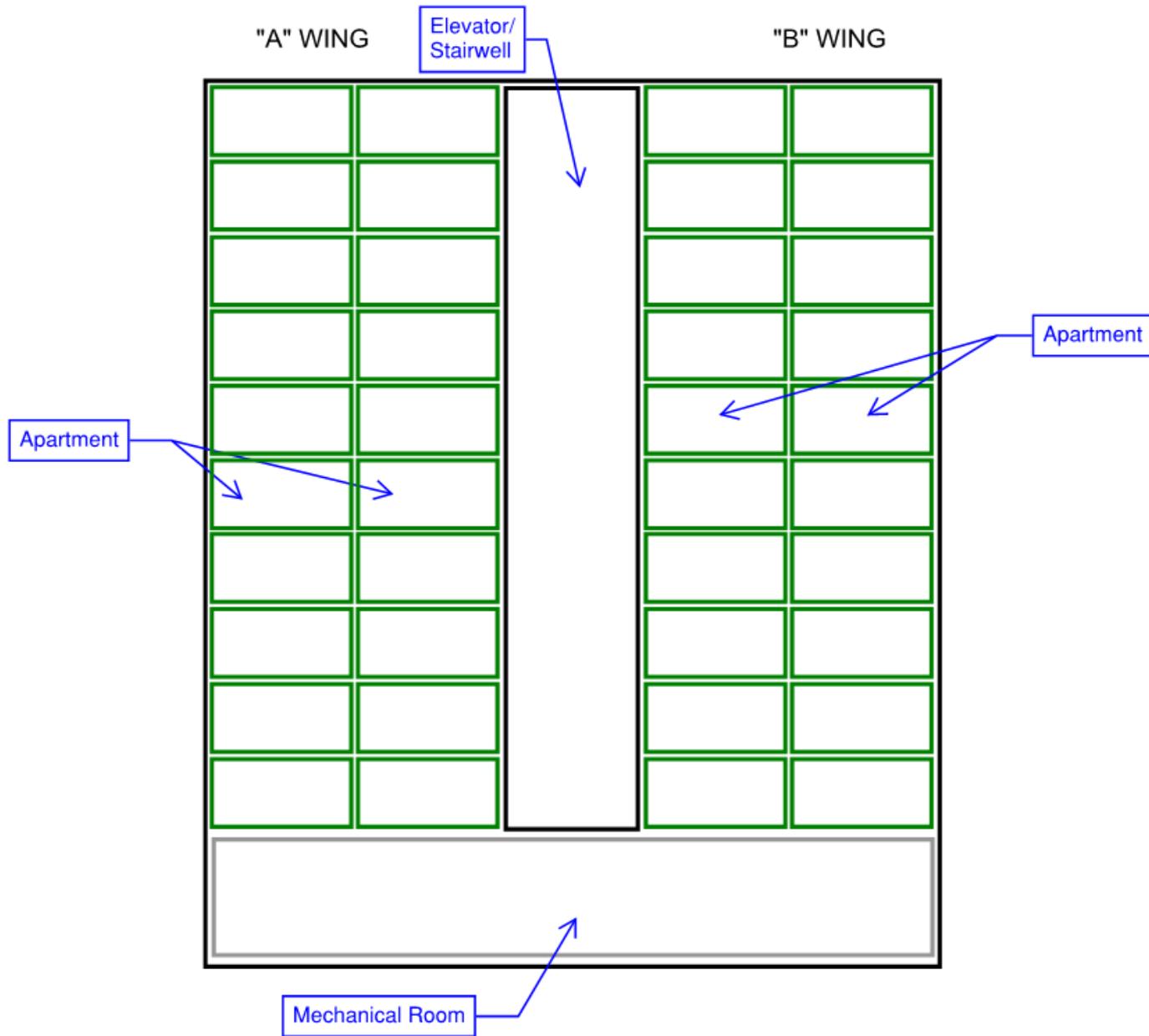
# Pipe Sizing

## Multi-family Apartment Building

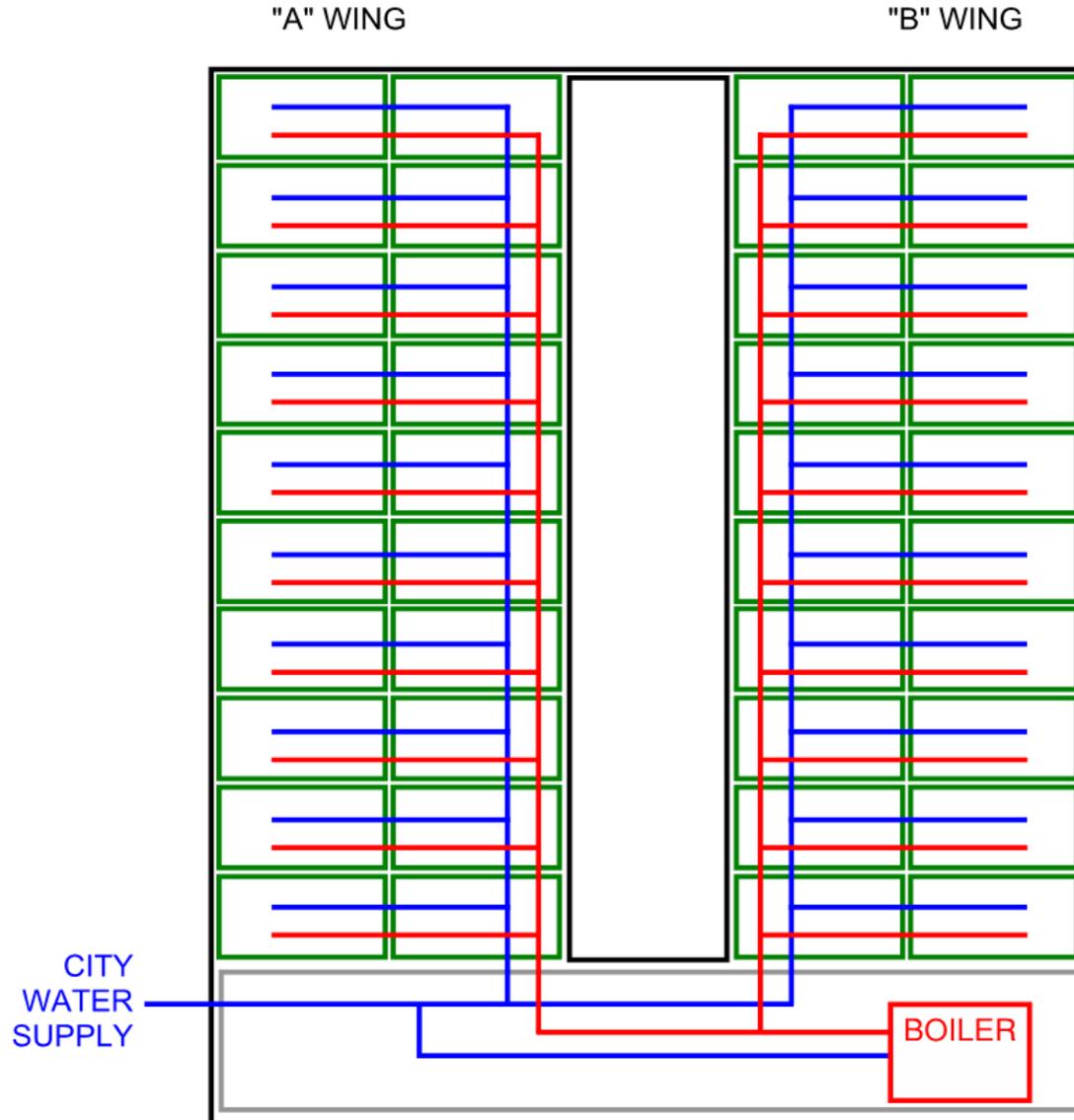
- 10 story
- 4 units per floor
- 40 total units



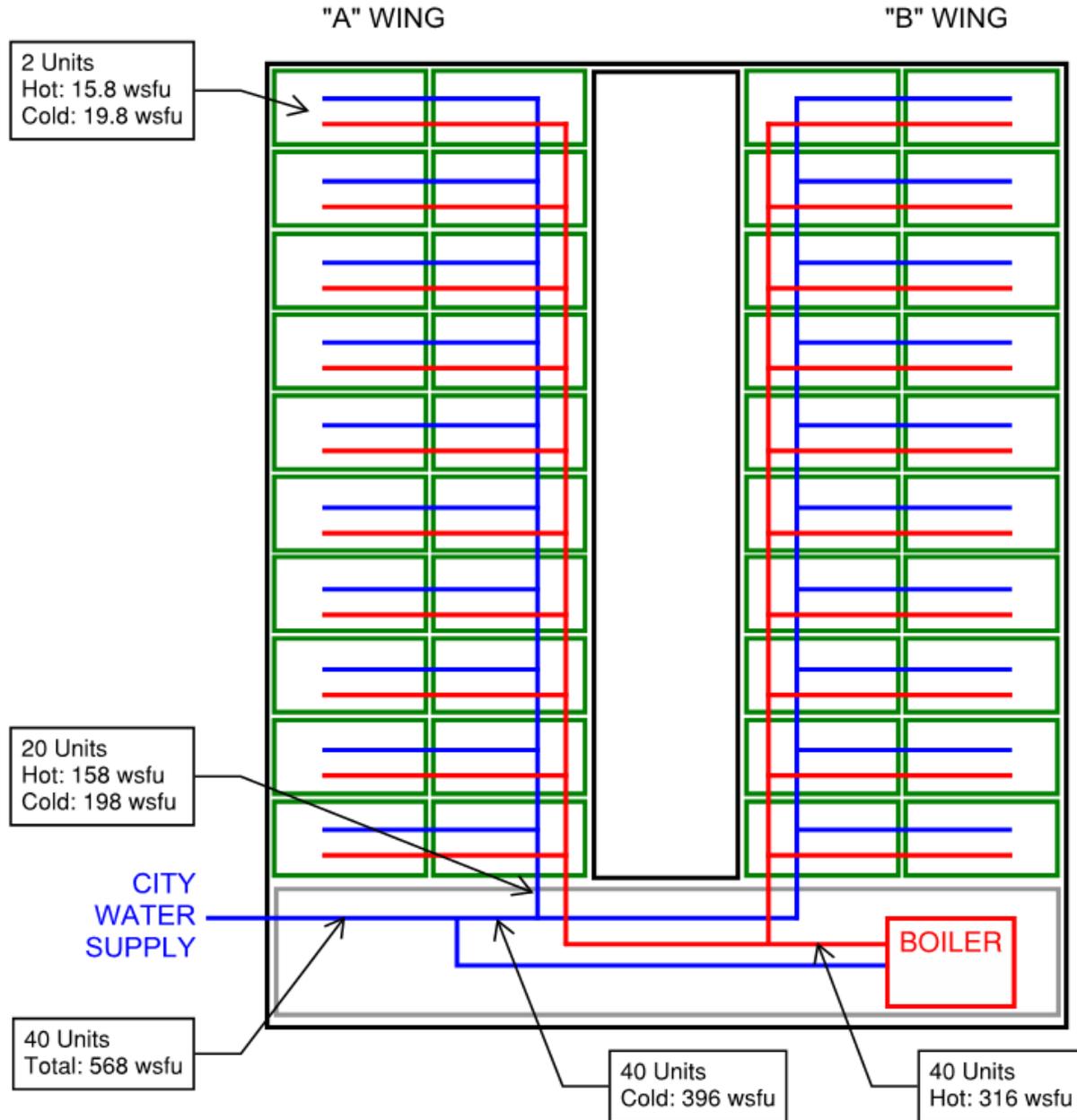
# Pipe Sizing



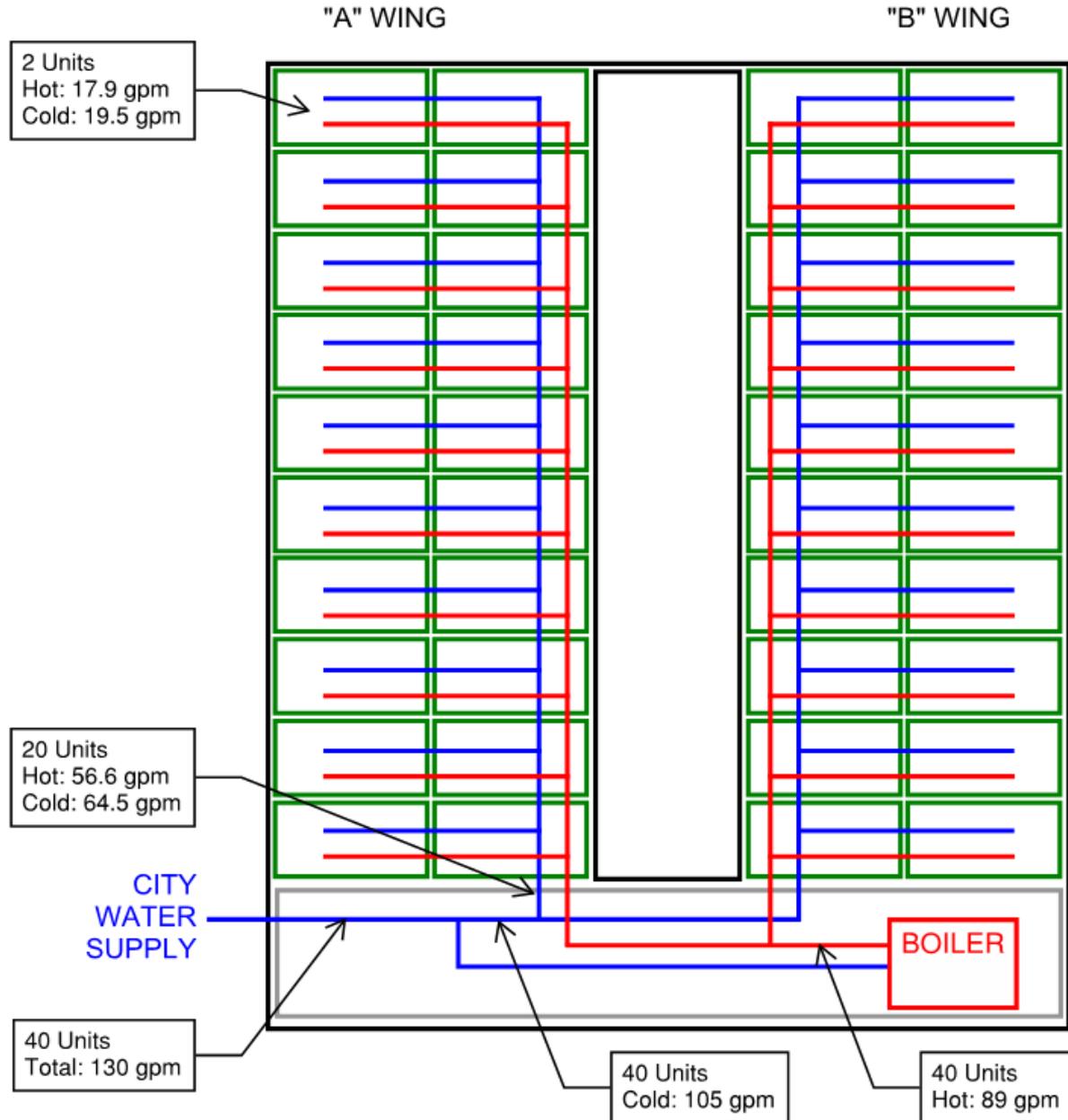
# Pipe Sizing



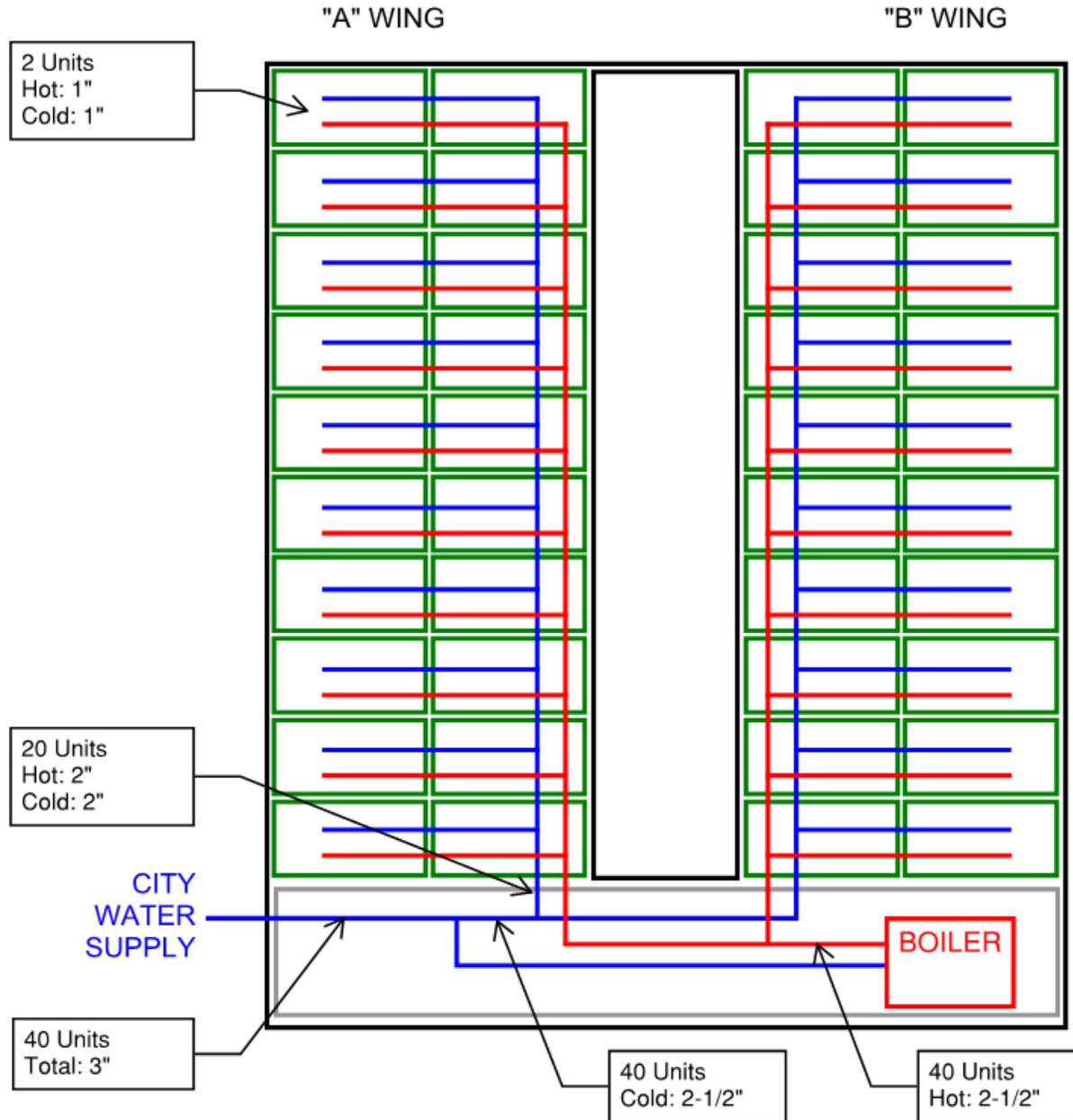
# Pipe Sizing – 2018 IRC



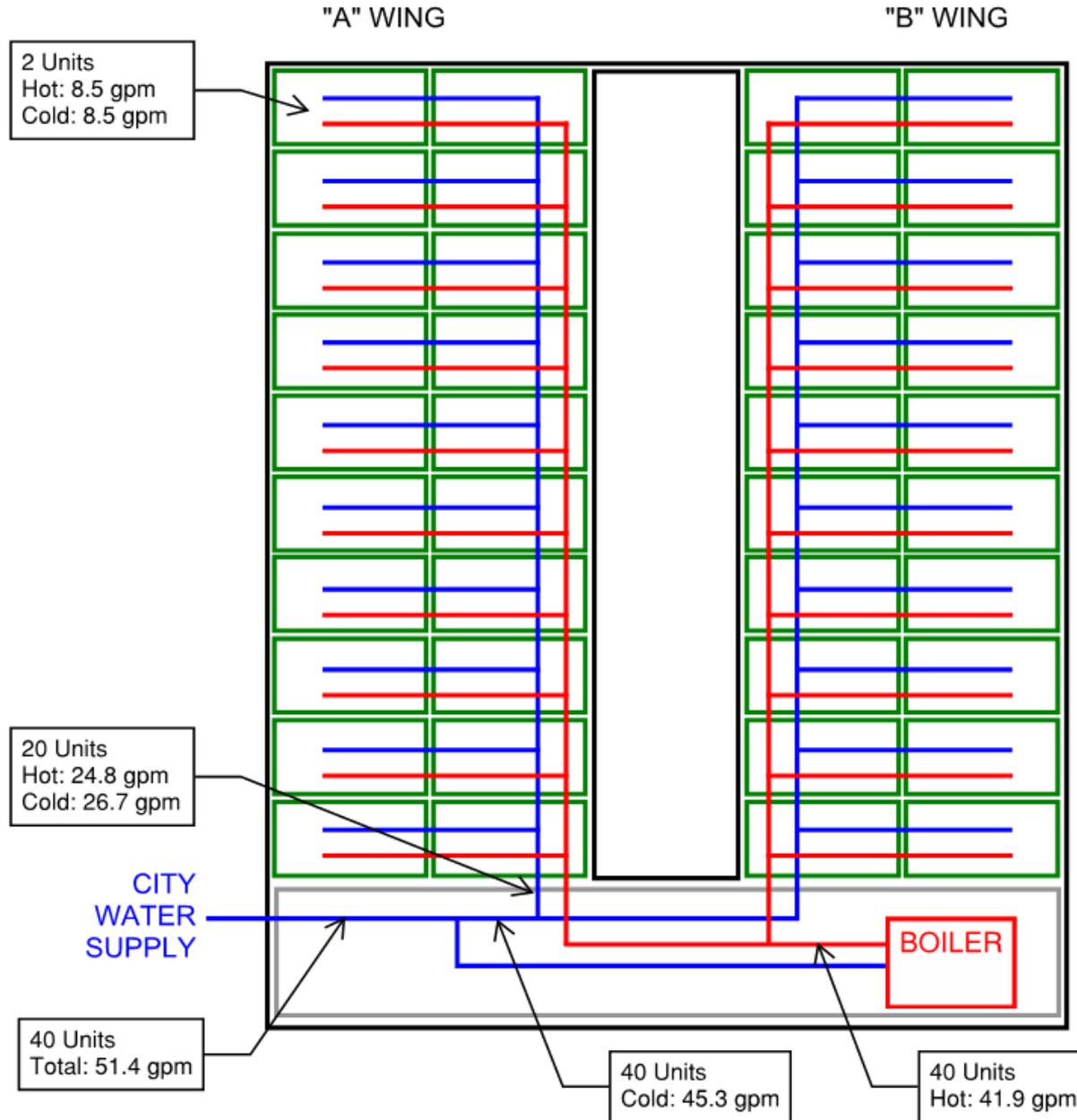
# Pipe Sizing – 2018 IRC



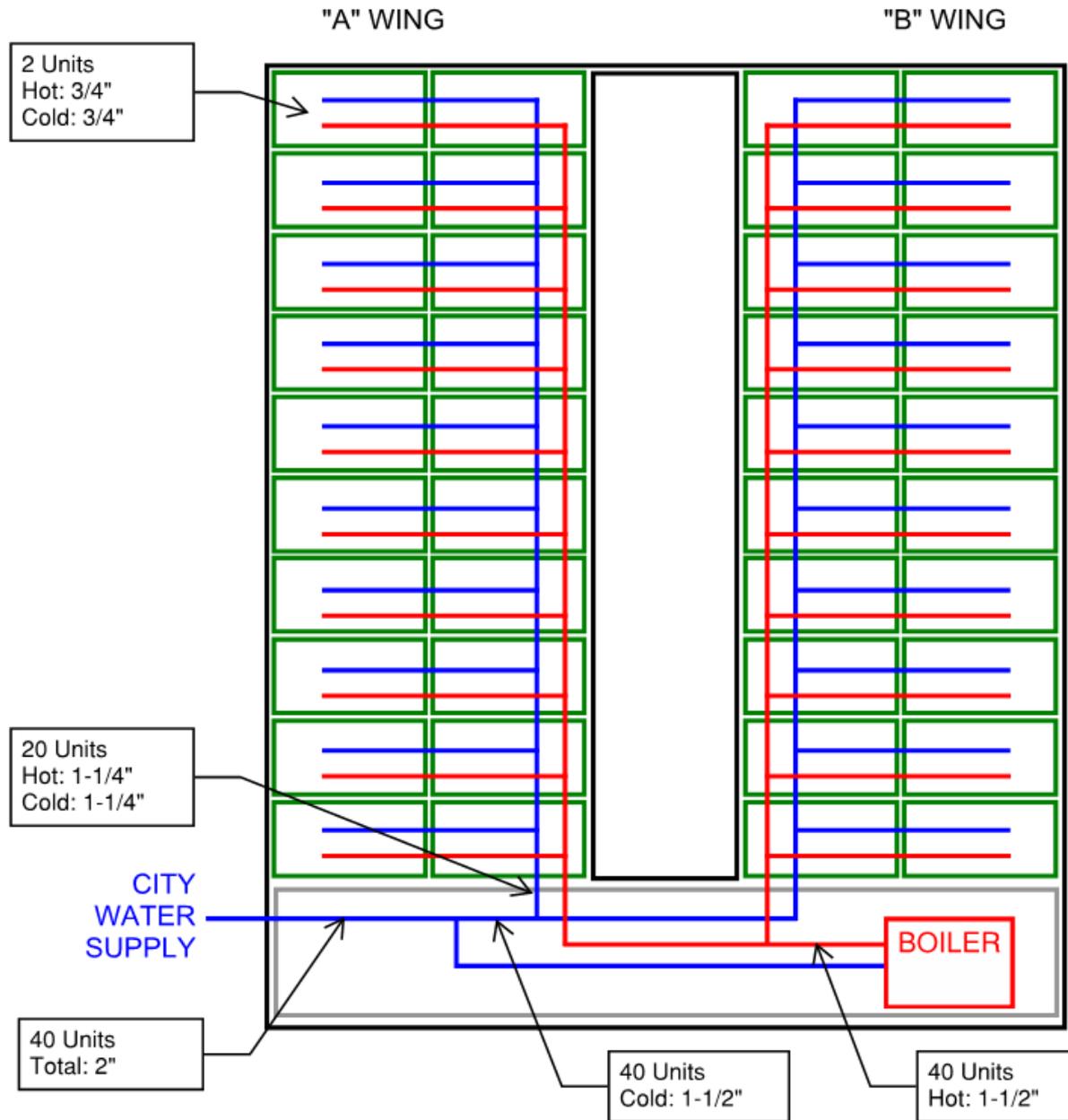
# Pipe Sizing – 2018 IRC



# Pipe Sizing – Appendix M



# Pipe Sizing – Appendix M



# Pipe Sizing – Comparison

## 2018 IRC

### 1 unit

Hot: 12.7 gpm (3/4")

Cold: 14.5 gpm (3/4")

### 2 units

Hot: 17.9 gpm (1")

Cold: 19.5 gpm (1")

### 20 units

Hot: 56.6 gpm (2")

Cold: 64.5 gpm (2")

### 40 units

Hot: 89 gpm (2-1/2")

Cold: 105 gpm (2-1/2")

**Total:** 130 gpm (3")

## Appendix M

### 1 unit

Hot: 6.5 gpm (1/2")

Cold: 6.5 gpm (1/2")

### 2 units

Hot: 8.5 gpm (3/4")

Cold: 8.5 gpm (3/4")

### 20 units

Hot: 24.8 gpm (1-1/4")

Cold: 26.7 gpm (1-1/4")

### 40 units

Hot: 41.9 gpm (1-1/2")

Cold: 45.3 gpm (1-1/2")

**Total:** 51.4 gpm (2")

# In General...

1. 2018 International Codes base pipe sizing on WSFU (water supply fixture units) which do not reflect actual fixture flow rates and water efficiency standards
2. Appendix M (IAPMO – 2018 UPC) is based on probabilities of simultaneous use from residential water use surveys and actual fixture flow rates
  1. Appendix M will generally result in a reduction of pipe size by 1 to 2 nominal sizes

# Questions?

*Thank you!*