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Water Demand Trends in the Multifamily Housing Sector

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Presentation Overview

- Background on WRF 4554
- Data sources and collection methods
- Metrics and comparisons
- Examples of modeling variability in water use
- Summary and “interim” conclusions

The Multifamily Housing Sector

- About 25% percent of housing (or about 33 million residences) in the U.S
- Share of multifamily dwellings increasing in some areas
- Multifamily housing dominant residential sector in some denser urban areas
- Many areas plan to direct future development or “densify”

Water Research Foundation Project 4554

- Water Use in the Multifamily Housing Sector
- Objectives
 - Narrow knowledge gaps
 - Develop, demonstrate, and recommend analytical strategies for:
 - Ø Estimating multifamily water use
 - Ø Categorizing multifamily properties
 - Ø Forecasting water use for water use categories

Defining what is “Multifamily”

- Everything other than traditional single-family detached homes
- Any residential property w/2+ units
- Master-metered residential properties
- General practice to lump MF into general residential or commercial customer classes
- Tenure can correlate with:
 - Presence of water end uses
 - How properties are maintained
 - How the cost of water service is distributed

Ownership/Tenure
Rental
Apartments
Duplex
Multiplex
Individually Owned
Condominiums
Townhouses
Jointly Owned
Cooperatives

What “Multifamily” looks like



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Selected Research Questions

- To what extent does multifamily water use differ from single-family use?
- How does water use differ among subclasses of the multifamily sector?
- What factors influence water use in the multifamily sector and major sub-classes?
 - Does greater development density lead to less use?
 - What are the effects of given property features?
 - Can we inform forecasting and evaluation efforts?

Data Collection

- Water use for “multifamily” properties or classes
- Number of dwelling units (scale measure)
- Sub-classifications
- Property characteristics
- Other potentially influential variables
 - Price
 - Income
 - Climatic
- Secondary information only

Utility Partners

Denver Water

New York City Dept. of
Environmental Protection

Phoenix Water Services

San Diego County Water
Authority

Tampa Bay Water

Other Key Data Sources

Fannie Mae

NYU Furman Center

Comparison of Unit Usage Rates (gallons per unit per day)

Utility	Multifamily Sector (Composite)		
	Units	Mean (Grand)	Median
Denver (2014)	192,560	133	127
New York City (2014)	2,143,108*	170	137
Phoenix (2014)	181,101	182	158
San Diego County (2012)	423,788	164	n/a
Tampa Bay Water (2014)	280,865	117	97
*Excludes properties designated as One-Family Dwelling or Mixed Residential/Commercial			

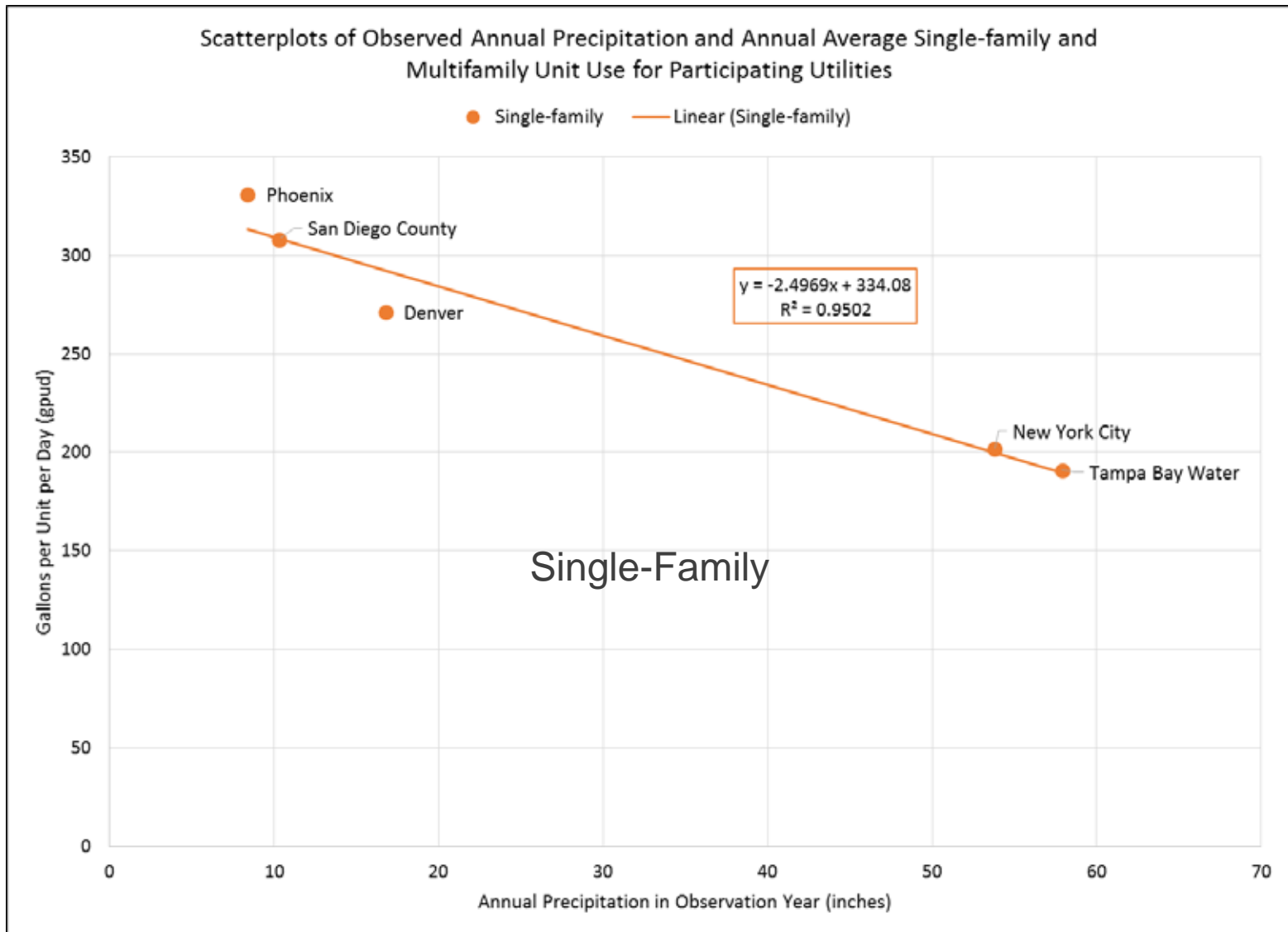
Relatively weak
association with
climate

Distributions
“skewed to the
right”

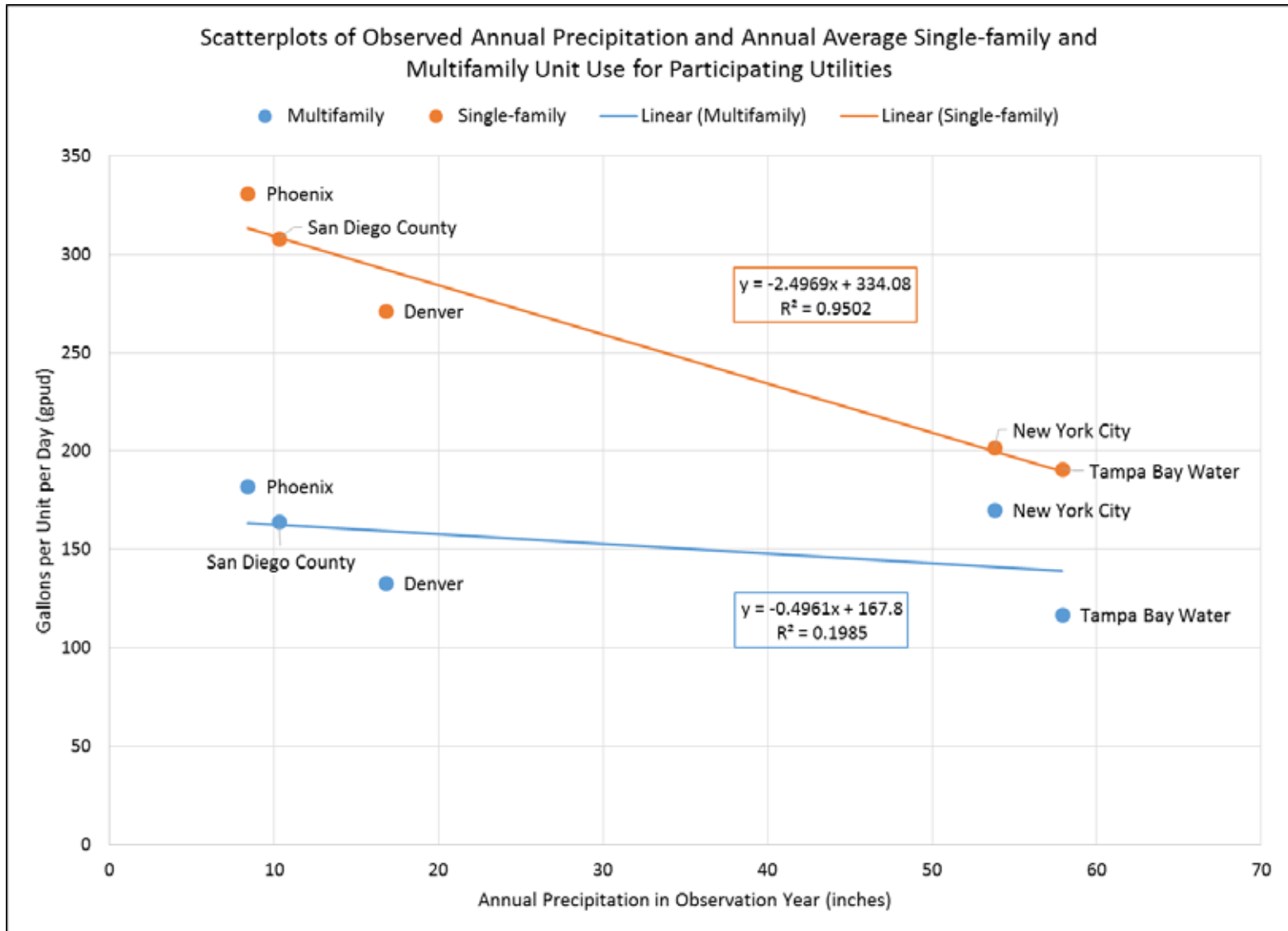
Comparison of Unit Usage Rates (gallons per unit per day)

Utility	Multifamily Sector (Composite)			Single-Family Sector			
	Units	Mean (Grand)	Median	Units	Mean	Median	
Denver (2014)	192,560	133	127	202,367	271	n/a	
New York City (2014)	2,143,108*	170	137	315,246	202	170	
Phoenix (2014)	MF < SF in all cases		182	158	305,341	331	242
San Diego County (2012)	423,788	164	n/a	670,692	308	n/a	
Tampa Bay Water (2014)	280,865	117	97	404,903	191	150	
*Excludes properties desig or Mixed Residential/Com	Stronger association with climate in SF sector						

Annual Precipitation and Average Unit Use

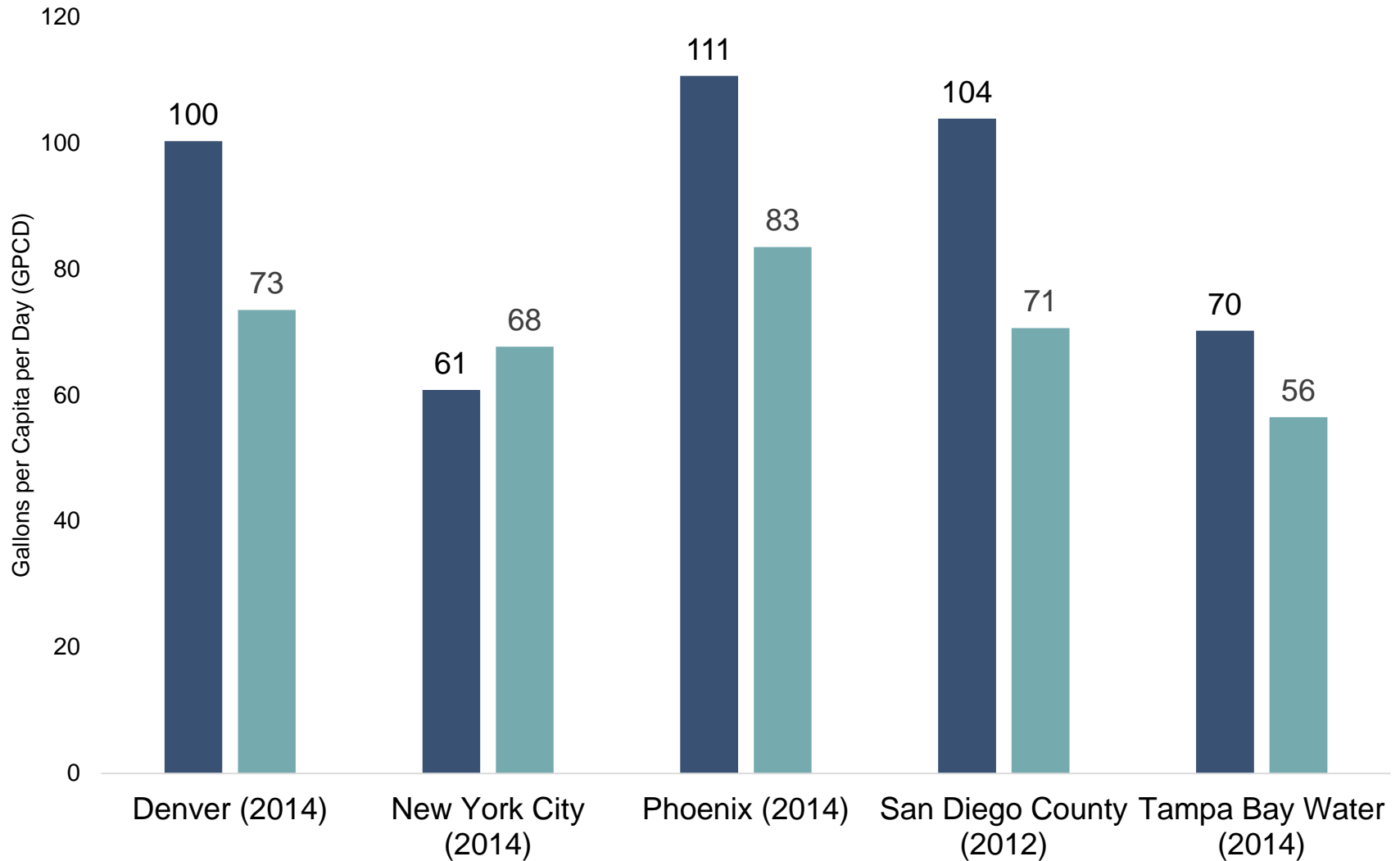


Annual Precipitation and Average Unit Use



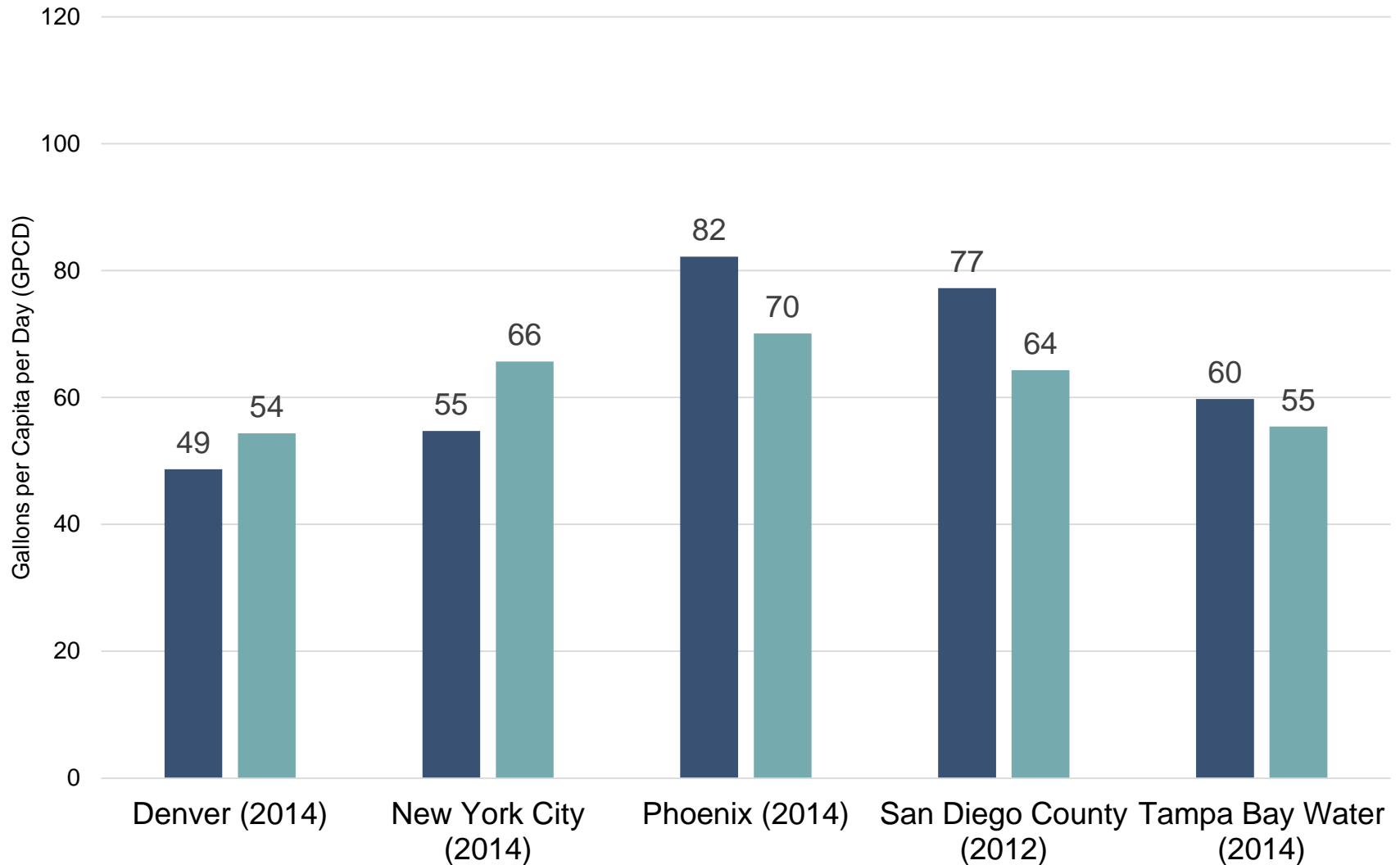
Estimated Average Annual Water Use **Per Capita** for Five Water Systems (gallons per capita per day)

■ Single-Family ■ Multifamily

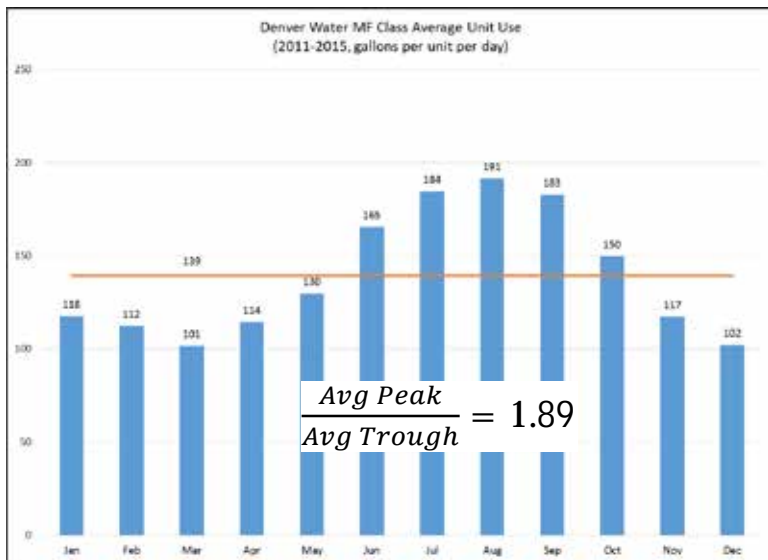


Estimated Average **"Min-Month"** Water Use **Per Capita** for Five Water Systems (gallons per capita per day)

■ Single-Family ■ Multifamily

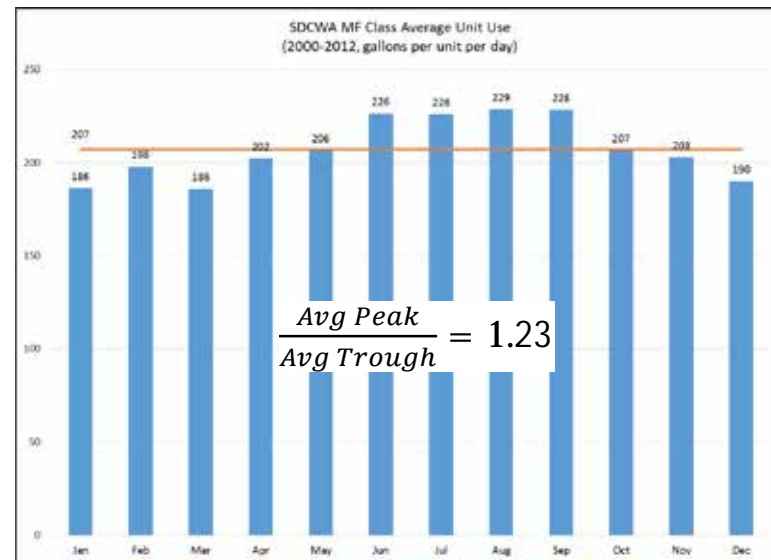


Denver (2011-2015)

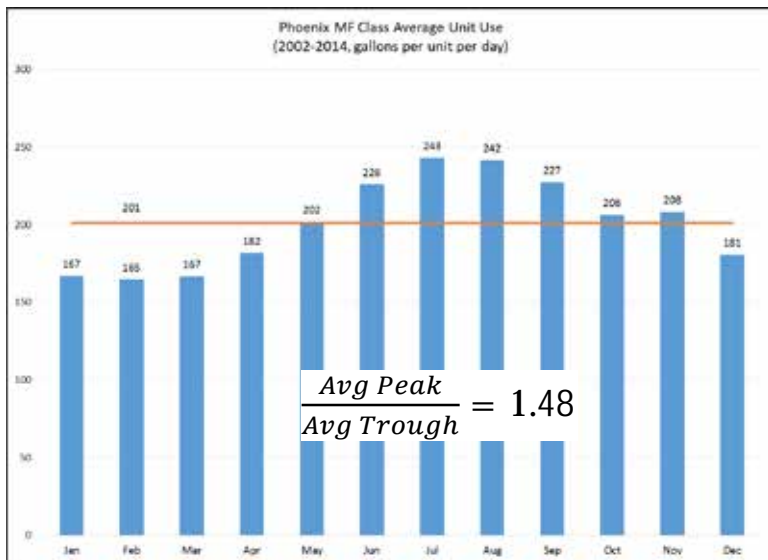


Average Seasonal Patterns

San Diego County (2000-2012)

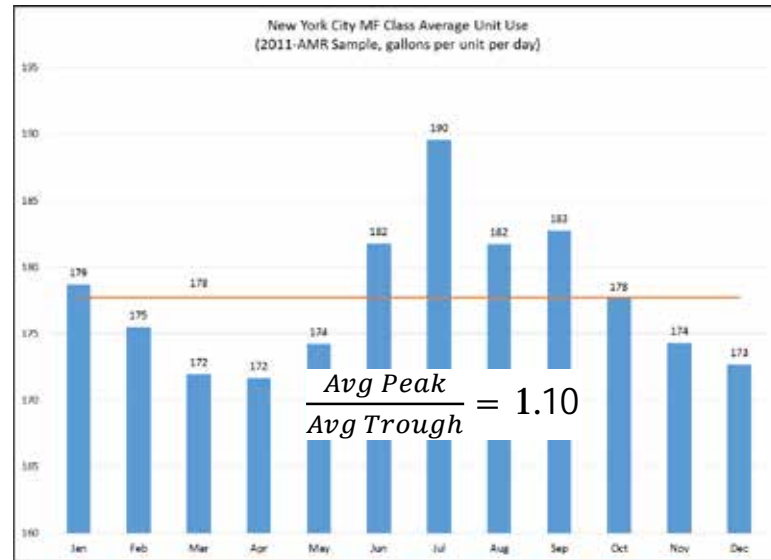


Phoenix (2002-2014)



Average Seasonal Patterns

New York City (2011-AMR Sample)



Tampa Bay Water (2002-2014)



Unique Seasonal Pattern

- Spring is dry season
- "Snowbirds" / Spring Break

Evaluation of Sub-Classification

- Do average usage patterns differ significantly based on definitional groupings?
 - Different utilities define multifamily sector differently
 - Different utilities sub-classify multifamily sector differently
- Analysis depends on use of external and linkable data
 - Land use codes
 - Property use codes
 - Building types

Sub-classification Example-Tampa Bay Water

Major Class	Subclass 1	Subclass 2	Premises	Dwelling Units	Avg Units per Premise	Avg GPUD 2014
Multifamily			19,606	280,865	14	117

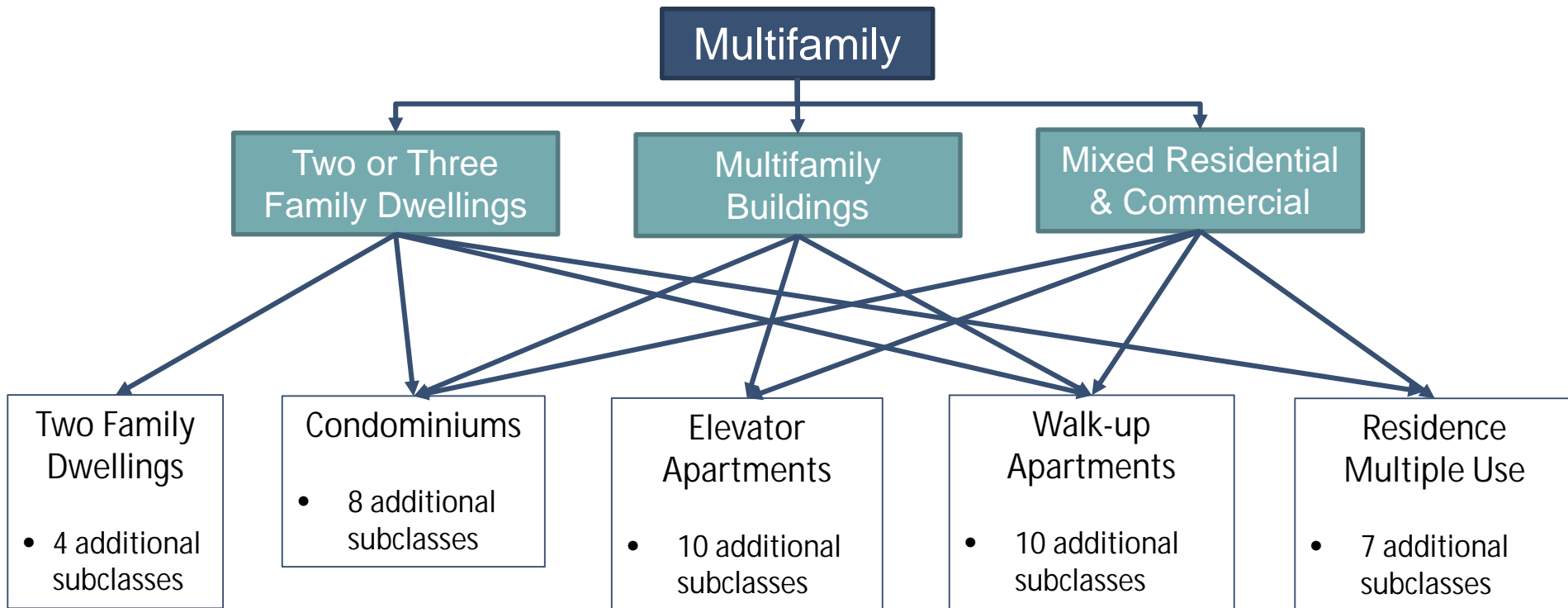
Sub-classification Example-Tampa Bay Water

Major Class	Subclass 1	Subclass 2	Premises	Dwelling Units	Avg Units per Premise	Avg GPUD 2014
Multifamily			19,606	280,865	14	117
Multifamily	Condo		1,325	72,613	55	116
Multifamily	Coop		83	1,668	20	64
Multifamily	MH		4,505	44,833	10	109
Multifamily	Townhouse		797	28,475	36	135
Multifamily	less than 10 units		11,933	31,823	3	102
Multifamily	more than 10 units		963	101,453	105	123

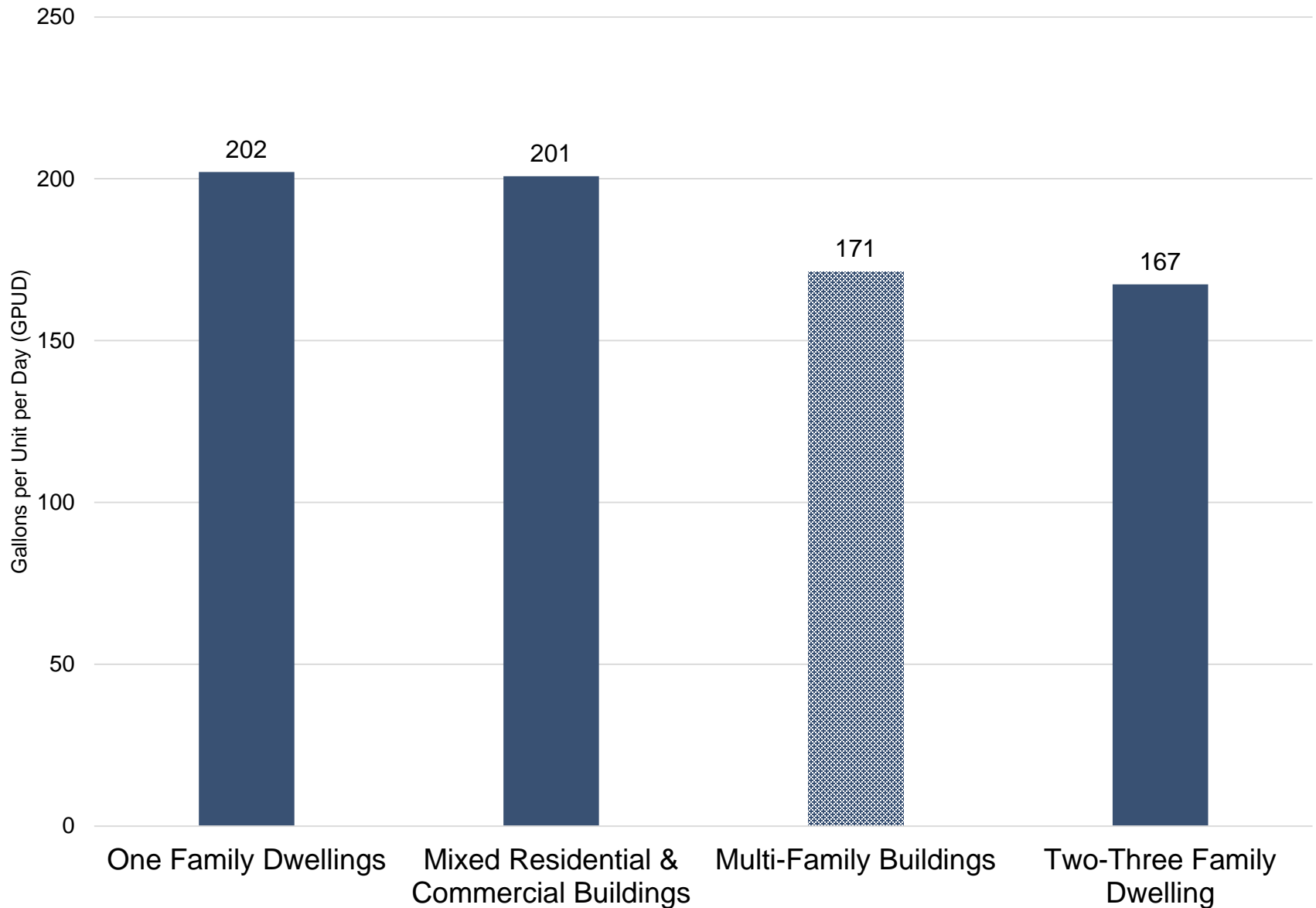
Sub-classification Example-Tampa Bay Water

Major Class	Subclass 1	Subclass 2	Premises	Dwelling Units	Avg Units per Premise	Avg GPUD 2014
Multifamily			19,606	280,865	14	117
Multifamily	Condo		1,325	72,613	55	116
		Condo/Coop	1,305	72,591	56	115
		Condo/Townhome Hdr/Ref	20	22	1	3,265
Multifamily	Coop	Misc Residential Coop	83	1,668	20	64
Multifamily	MH		4,505	44,833	10	109
		MH Park	237	17,663	75	150
		MH Park Coop	257	23,024	90	68
		SF/MH	4,011	4,146	1	160
Multifamily	Townhouse		797	28,475	36	135
Multifamily	less than 10 units		11,933	31,823	3	102
Multifamily	more than 10 units		963	101,453	105	123

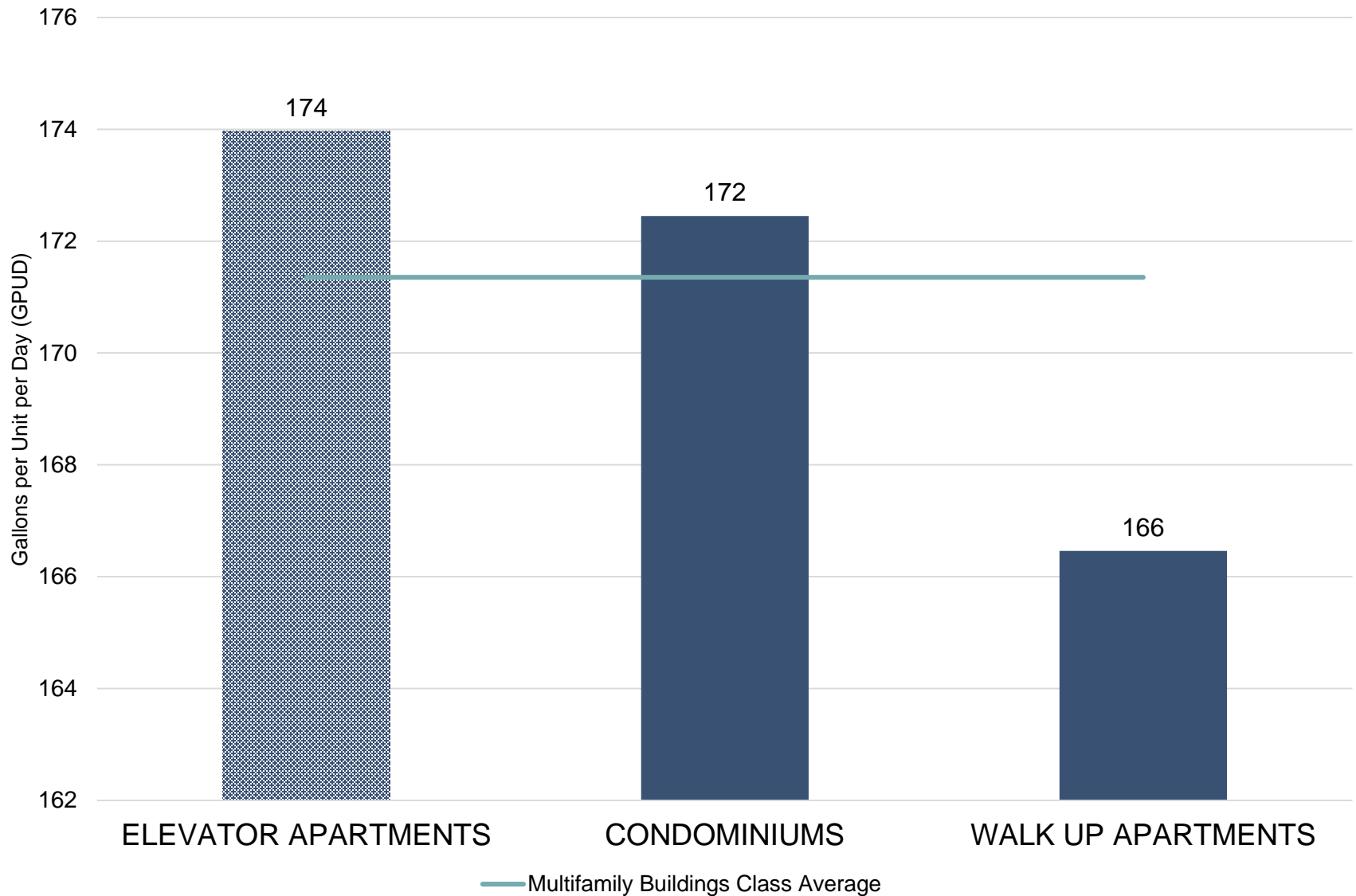
New York City Classifications



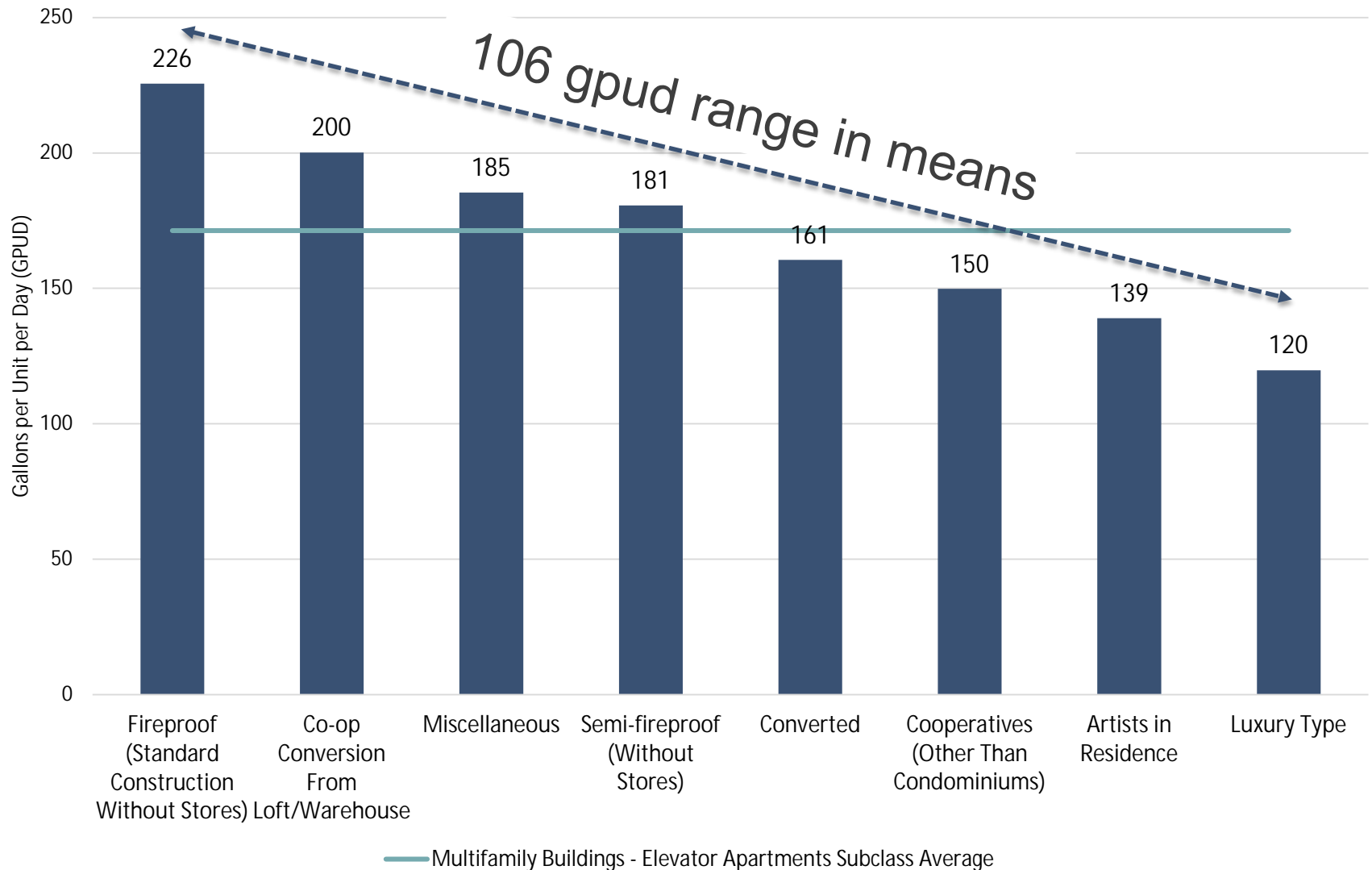
New York City Mean 2014 Unit Use by Residential Land Use Tax Classes (GPUD)



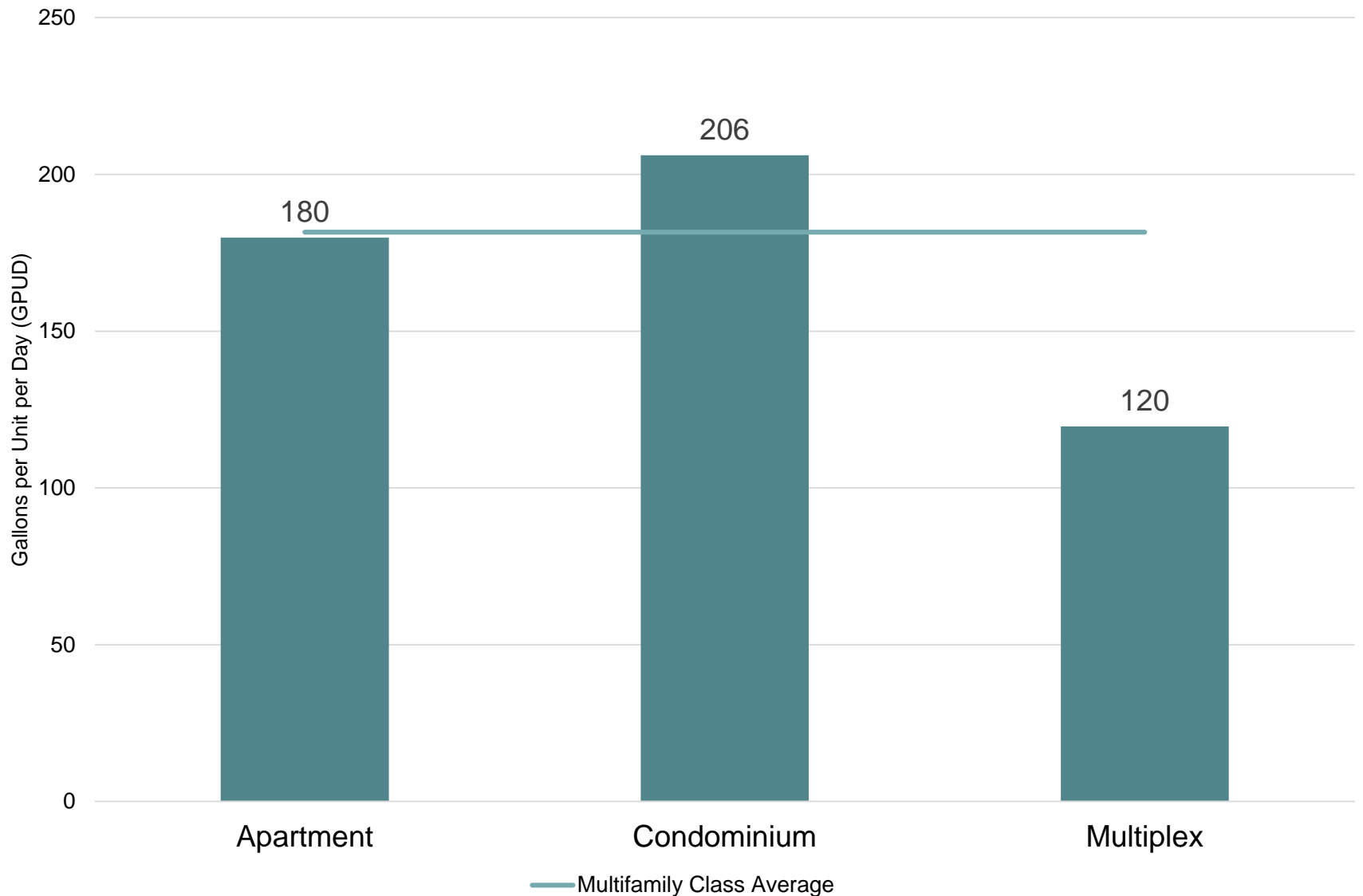
New York City Mean 2014 Unit Use for Building Classes within "Multifamily Buildings" Land Use Tax Class (GPUD)



New York City Mean 2014 Unit Use for Building Sub-Classes within "Elevator Apartments" Building and "Multifamily Buildings" Land Use Tax Class (GPUD)

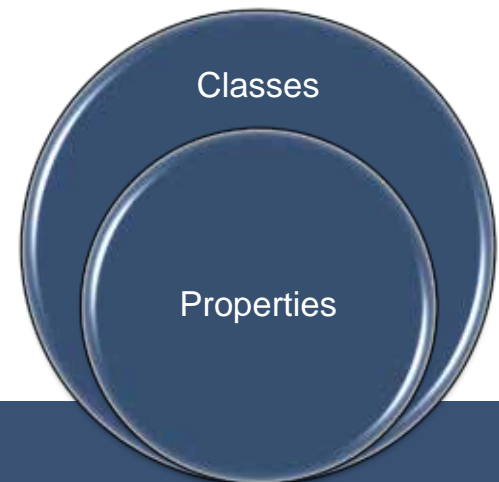


Phoenix 2014 Multifamily Annual Average Unit Usage Rates by Major Subclass (gallons per unit per day)



Assessment of Multifamily Demand Determinants

- Regional water use and socioeconomic database for 22 retail agencies in San Diego County
- Property-level water use and survey data from 2012 Fannie Mae Multifamily Market Research Energy and Water Survey
- Utility-provided databases with selected property attribute and geographic assignments
 - Tampa Bay Water
 - Phoenix
 - New York City
 - Denver



Multifamily Class-level Forecast Model (San Diego County)

- Balanced panel model of water use, socioeconomics, weather, and climate
- 22 agencies, 120 months each

Variable	Estimated Multifamily Elasticity
Marginal Price for Water (inflation-adjusted)	-0.14
Median Household Income (inflation-adjusted)	+0.07
Housing Density (housing units per acre)	-0.30
Household Size	+0.56

Multifamily Class-level Forecast Model (San Diego County)

- Balanced panel model of water use, socioeconomics, weather, and climate
- 22 agencies, 120 months each

Variable	Estimated Multifamily Elasticity		Estimated Single-Family Elasticity
Marginal Price for Water (inflation-adjusted)	-0.14	<	-0.23
Median Household Income (inflation-adjusted)	+0.07	<	+0.54
Housing Density (housing units per acre)	-0.30		-0.31
Household Size	+0.56	>	+0.44

Estimated Socioeconomic Effects for Tampa Bay Water

Project data supporting Tampa Bay Water's forecast model re-development

Multifamily Class	Price Elasticity	Income Elasticity
All Multifamily	-0.13	+0.29
Condo	-0.20	+0.32
Townhouse	-0.41	+0.88
Less than 10 Units	-0.01	+0.29
10 or more Units	-0.14	+0.31
Mobile Home (single unit)	-0.01	+0.34
Mobile Home (multiple unit/parks)	-0.16	+0.30
Single-Family	-0.37 to -0.73	+0.37 to +0.45

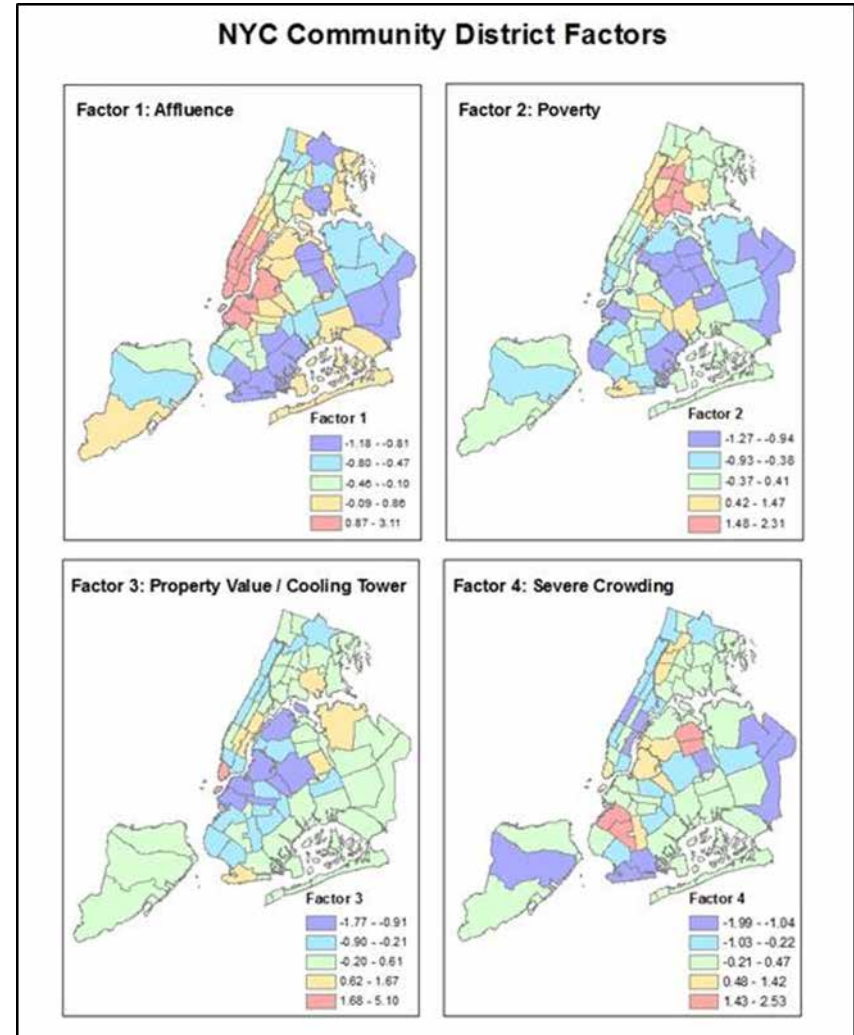
Factor Analysis of NYC Community Districts

Socioeconomic data from NYU Furman Center available for 64 metrics across 59 Community Districts

1. Aggregate premise level water use data to community district level
2. Condense demographic metrics into fewer “thematic” factors
3. Evaluate median water use per dwelling unit with respect to factor scores

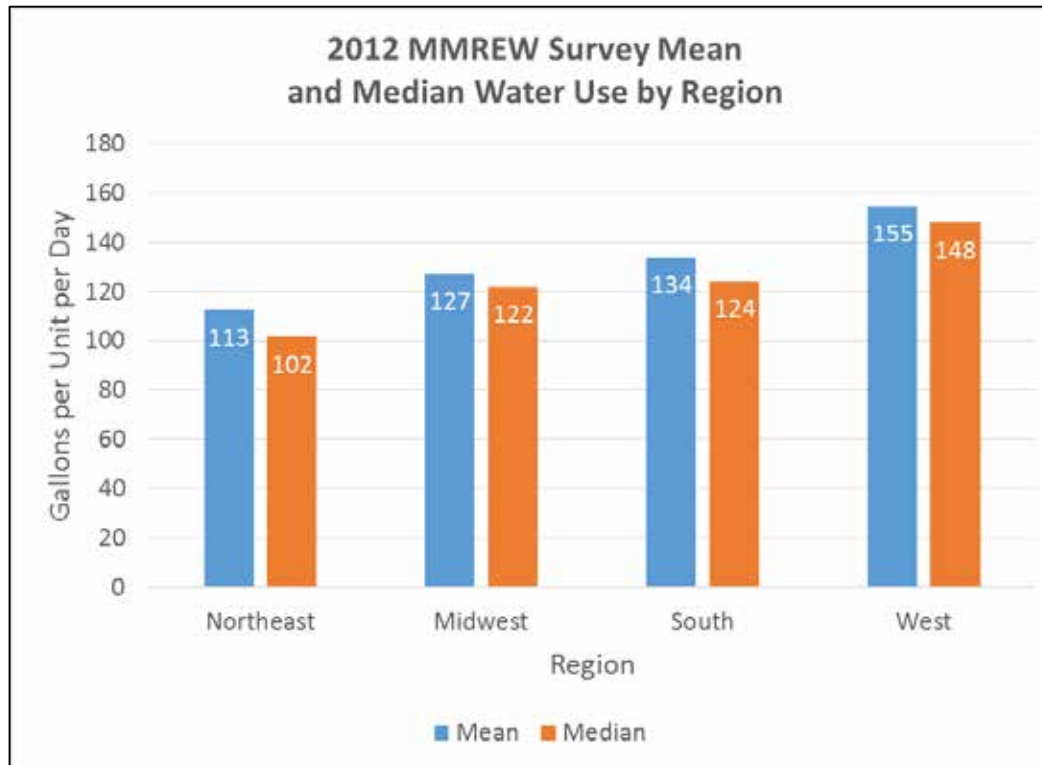
Factor Analysis of NYC Community Districts

Thematic Factor	Estimated Effect of 1 unit change in factor score
“Affluence”	-18 gpud
“Poverty”	+23 gpud
“Property Value/Cooling Towers”	+8 gpud
“Severe Crowding”	+15 gpud



Property-level Assessments (Fannie Mae Survey)

- Sample of 955 multifamily properties for 2012 categorized by region




Property-level Assessments (Fannie Mae Survey)

- Regression analysis of cross-sectional data on multifamily property features, accounting for region (n=323)

Variable	Estimated Elasticity or Effect
Average Cost of Water	-0.26
Presence of Pool	+10%
Tenant Pays for Water	-17%
Property Receives Govt Subsidy	-12%
Property Built \geq 2001	-16%
Senior Living Facility	-18%

Level + Mechanism



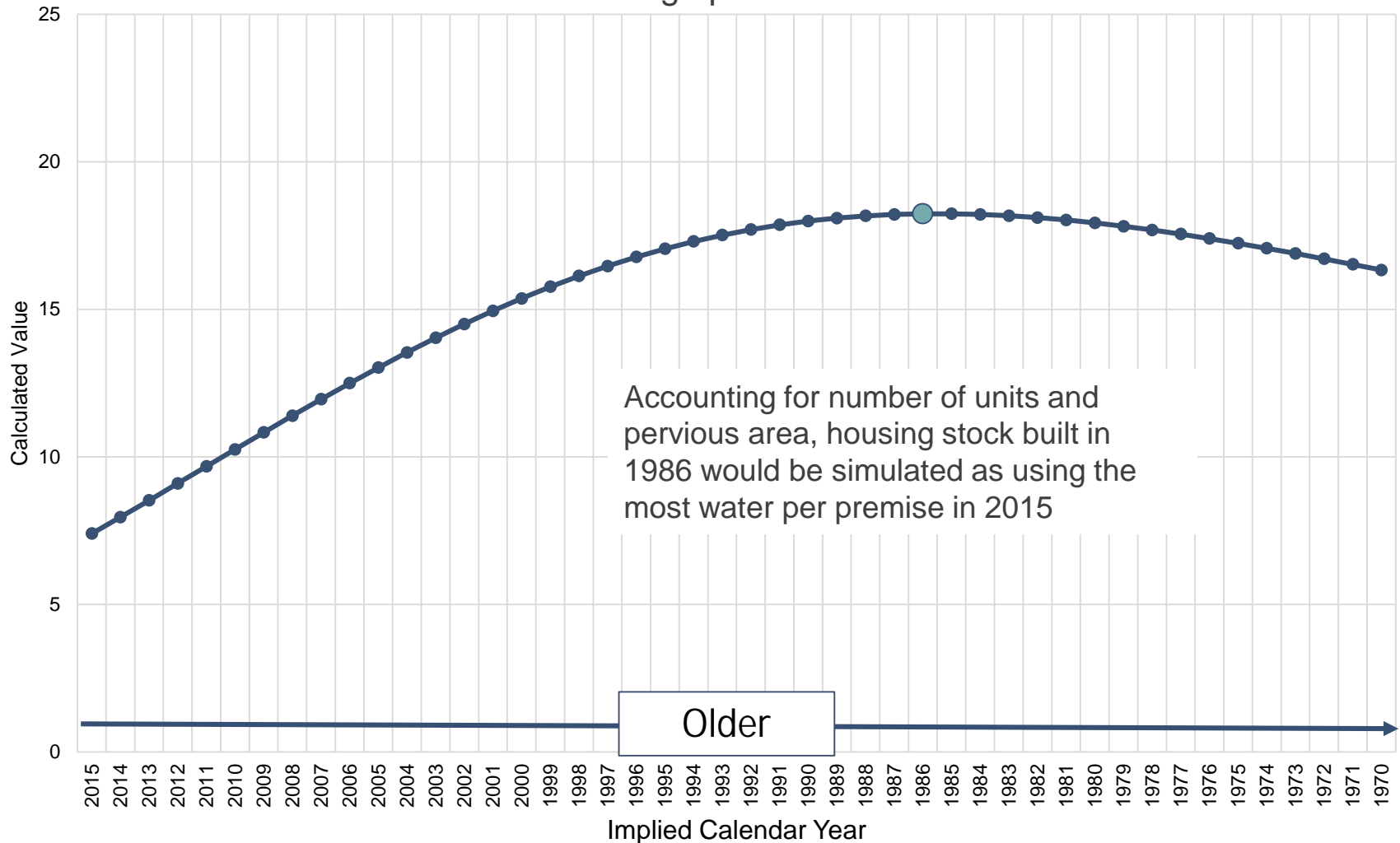
Data Available from Utility Partners for Property-level Assessments

System	Units	Lot Size	Year Built	Assessed Value	Presence of Pool(s)	Presence of Reclaimed Water	Presence of Cooling Tower(s)
Denver	X	X (pervious area)	X				
New York City	X	X	X	X			X
Phoenix	X	X	X		X (Apt only)		X (Apt only)
Tampa Bay Water	X	X	X	X	X	X	

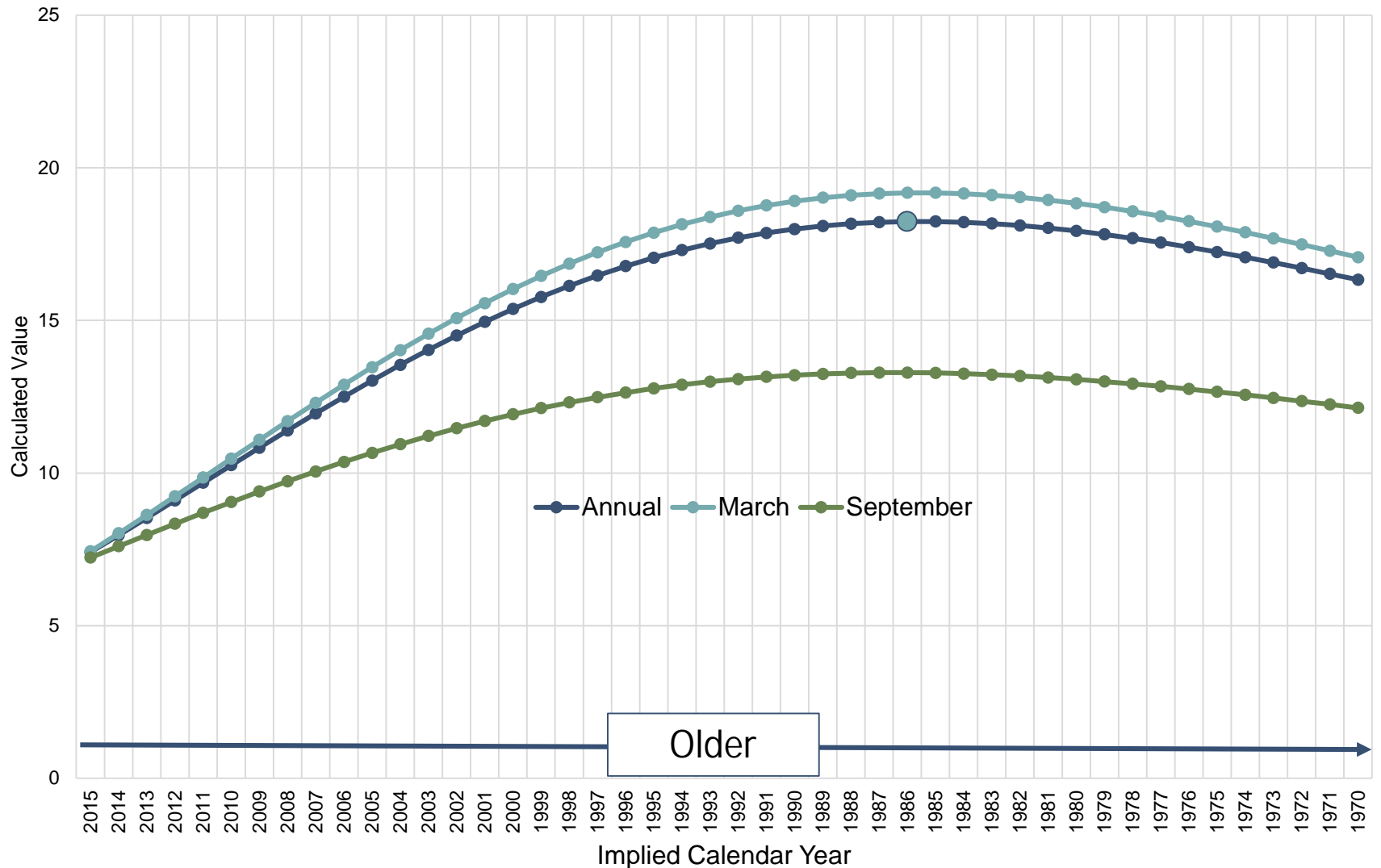
System	Class	Density (Units/Acre) Elasticity	Assessed Value Elasticity	Effect of Pool(s)	Effect of Reclaimed Water	Effect of Cooling Tower(s)	Age Profile
Denver (2015)	Multifamily Total	-0.18					
Tampa Bay Water (2010-2014 average)	Multifamily Total	-0.14	0.10	9.4%	-20.5%	Access to alternative supplies has significant effect on TBW demands	
	Condo	-0.14	0.09	7.8%	-18.2%		
	Townhouse	-0.06	0.21	13.0%	-18.4%		
	Less than 10 Units	-0.05	All estimates negative and statistically significant				
	10 or More Units	-0.21					
Phoenix (2010-2014 average)	Multifamily Total	-0.44					+++
	Apartment	-0.45		20.3%		28.7%	+++
	Condo	-0.54					+-
	Multiplex	-0.23	Impact of cooling towers proportionally larger in the desert				+++
New York City (2014)	Condominiums	-0.14				18.4%	+++
	Elevator Apartments	-0.20	-0.04			15.7%	+++
	Walk-up Apartments	-0.08	-0.01			5.8%	+++

Plot of Building Age Portion of Regression Equation
 $= \text{Exp}(1.9247 + 0.0789 \cdot \text{AGE} - 0.0021 \cdot \text{AGE}^2 + 1.9756 \cdot 10^{-5} \cdot \text{AGE}^3 - 6.3819 \cdot 10^{-8} \cdot \text{AGE}^4)$

Denver Age profile: +--+



Plot of Building Age Portion of Regression Equation



Summary and Interim Conclusions

- Water use in the Multifamily sector differs from water use in the Single-family sector
 - Per dwelling unit
 - Per capita
- Evidence that water use is seasonal
 - Weather-sensitive end uses
 - Seasonal occupancy
- For a given climate, generally lower seasonal use in the MF sector relative to SF
- The gap between SF and MF unit usage rates narrows when accounting for household size and seasonality

Summary and Interim Conclusions

- Development density is statistically important
- More units per acre (i.e., higher unit density) - lower unit usage rates
- Results are consistent with the notion of shared outdoor (and other) uses
- MF is denser than SF
- More dense MF, generally less water use (per dwelling unit)

Summary and Interim Conclusions

- Water use in the MF sector is influenced by
 - Climate and weather
 - Property features (water end uses)
 - Socioeconomics
 - Price
- The estimated effects of water use determinants tend to vary by geographic area
 - Underlying climate
 - Sector/subclass structure

Summary and Interim Conclusions

- The ability to obtain information on housing units is essential for accounting for scale
- Obtaining information on units typically permits additional classification options
- Sub-classification can affect sample statistics and modeling relationships – this may matter for certain planning and evaluation purposes

Thanks!

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