



# **Incorporating End Use into Demand Forecasting**

## **3<sup>rd</sup> Urban Water Demand Roundtable**

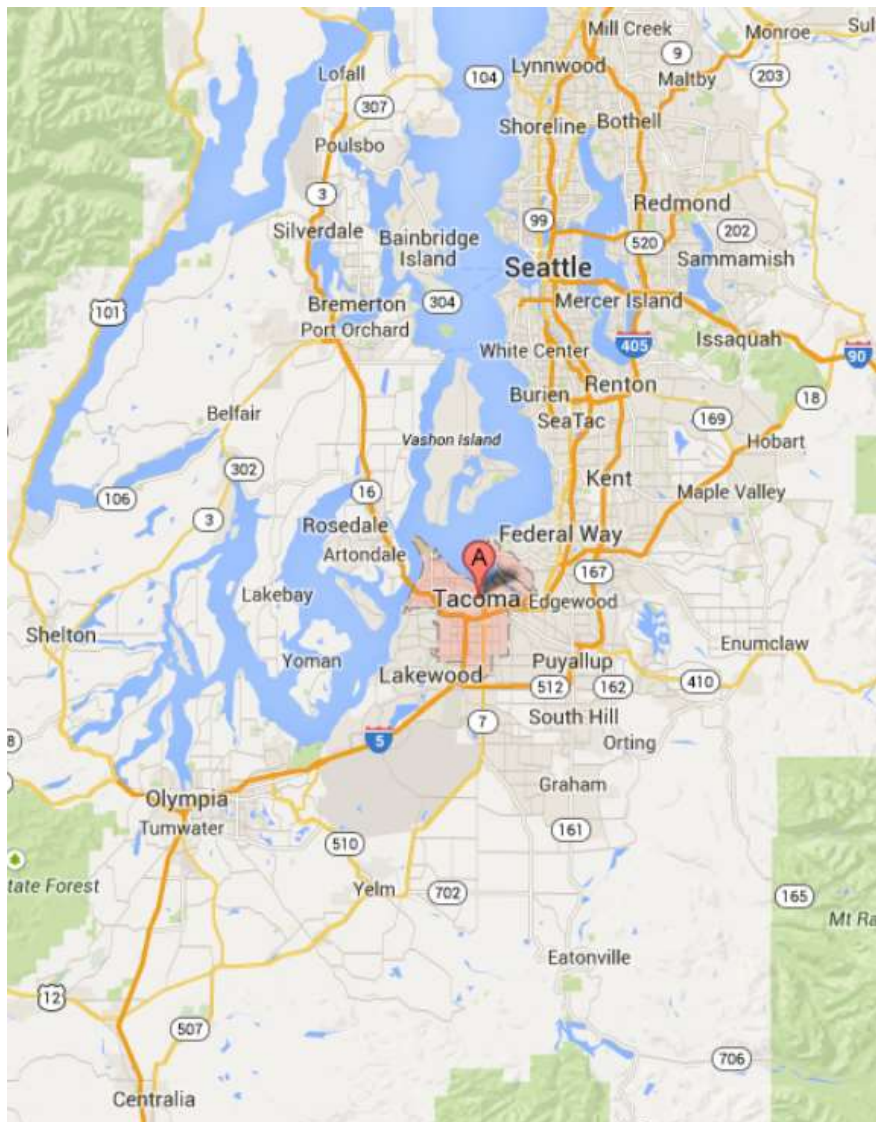
**February 2015**

- **Bill Zimmerman**
  - **M.Sc. in Economics**
    - Hanken School of Economics (Helsinki, Finland 2011)
  - **B.A. in Economics**
    - Western New England University (Springfield, MA 2007)
  - **Economist at Tacoma Water's Rates and Financial Planning group a division of Tacoma Public Utilities for three years**
    - Short-term (10yr) forecasting for financial purposes
    - Long-term (60yr) forecasting for contracting, yield, and capital projects
    - Cost of service analysis and rate design
    - Market-based pricing framework for wholesale water sales
    - Databasing and customer reporting

# Goal & Contents

- **Goal:** Teach you how to incorporate end use data into your forecast to provide meaningful results
- **Contents**
  - Orientation
  - Data
  - Post-processing
  - Conclusions and Q&A

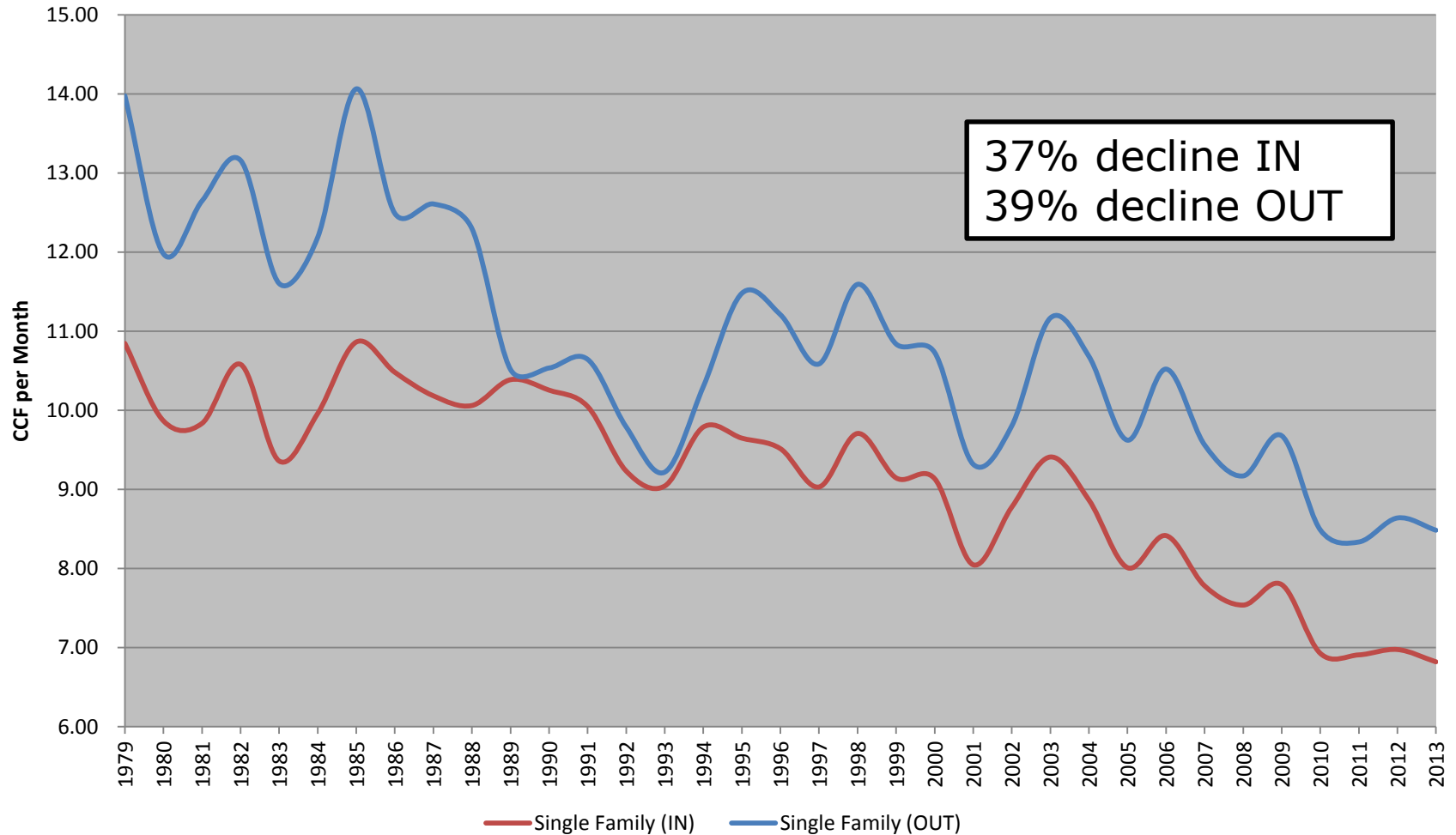
# Orientation: Tacoma Water



- **City of Tacoma**
  - Population of ~200,000
- **Tacoma Water**
  - Service area population ~320,000
  - 97,000 accounts
  - 49.8 MGD average day demand (2013)
  - 79.2 MGD peak day demand (2013)
- **Customer Composition (demand)**
  - Residential 43%
  - Commercial 15%
  - RockTenn 32%
  - Wholesale 7%
  - Irrigation 3%

# Orientation: Declining Demand <sup>5</sup>

## Single Family Residential Billed Demand per Account 1979 to 2013



- **Assumptions for end-use fixtures**
  - Fixed technology
  - Exponential or logarithmic declines to the technological limit
  - Data limitations
    - Every household declines at the same rate
    - Outdoor use has no lower limit
    - Fixed population per household
    - Some fixtures are held constant (“other” and “leak”)

Sample Utilities – Fixture Average Daily Use per Household (gpdph)										
	Sink	Toilet*	Shower	Bath	Leak	Washer*	Dishwasher*	Other	Indoor	Outdoor
<b>Sample 1999</b>	26.77	45.23	31.09	5.22	21.99	40.26	3.21	8.41	182.18	239.30
<b>Sample 2010</b>	26.35	33.08	28.08	3.62	17.04	22.76	1.58	5.18	137.69	94.00

- Consulting firm Aquacraft conducted two studies
  - 1999 End-Use Study
  - 2010 End-Use Study ← Tacoma Water participated in this
- Some utilities participated in both studies
- When testing for significant change between the two studies some were
  - Insignificant ← declines were not large enough to draw conclusions
    - Sink, Shower, Bath, Leak, Other
  - Significant (\*) ← declines were large enough to draw conclusions
    - Toilet, Washer, Dishwasher
- Because of the similarities found in the studies between utilities Tacoma Water may be able to adjust our 2010 stats to the sample utilities and adjust our stats to match consumption in 1999

# Data: Building Two Data Points

- First we need to find out how Tacoma Water fixture stats look compared to the 2010 Sample

	Average Daily Use per Household (gpdph)										
	Sink	Toilet*	Shower	Bath	Leak	Washer*	Dishwasher*	Other	Indoor	Outdoor	Total
Sample 2010	26.4	33.1	28.1	3.6	17.0	22.8	1.6	5.2	137.7	94.0	231.7
Tacoma 2010	25.1	34.7	25.9	3.1	13.5	22.9	2.0	0.4	127.6	56.3	183.9

- $Adjustment = \frac{Tacoma\ 2010_f}{Sample\ 2010_f}$

	Average Daily Use per Household (gpdph)										
	Sink	Toilet*	Shower	Bath	Leak	Washer*	Dishwasher*	Other	Indoor	Outdoor	Total
Sample 2010	26.4	33.1	28.1	3.6	17.0	22.8	1.6	5.2	137.7	94.0	231.7
Tacoma 2010	25.1	34.7	25.9	3.1	13.5	22.9	2.0	0.4	127.6	56.3	183.9
Adjustment	-5%	5%	-8%	-14%	-21%	1%	27%	-92%	-7%	-40%	-21%

- $Tacoma\ 1999_f = Adjustment_f \times Sample\ 1999_f$

	Average Daily Use per Household (gpdph)										
	Sink	Toilet	Shower	Bath	Leak	Washer	Dishwasher	Other	Indoor	Outdoor	Total
Sample 1999	26.8	45.2	31.1	5.2	22.0	40.3	3.2	8.4	182.2	239.3	603.7
Adjustment	-5%	5%	-8%	-14%	-21%	1%	27%	-92%	-7%	-40%	-21%
Tacoma 1999	25.5	47.4	28.7	4.5	17.4	40.5	4.1	0.6	168.8	143.3	479.1



# Data: Outdoor & History

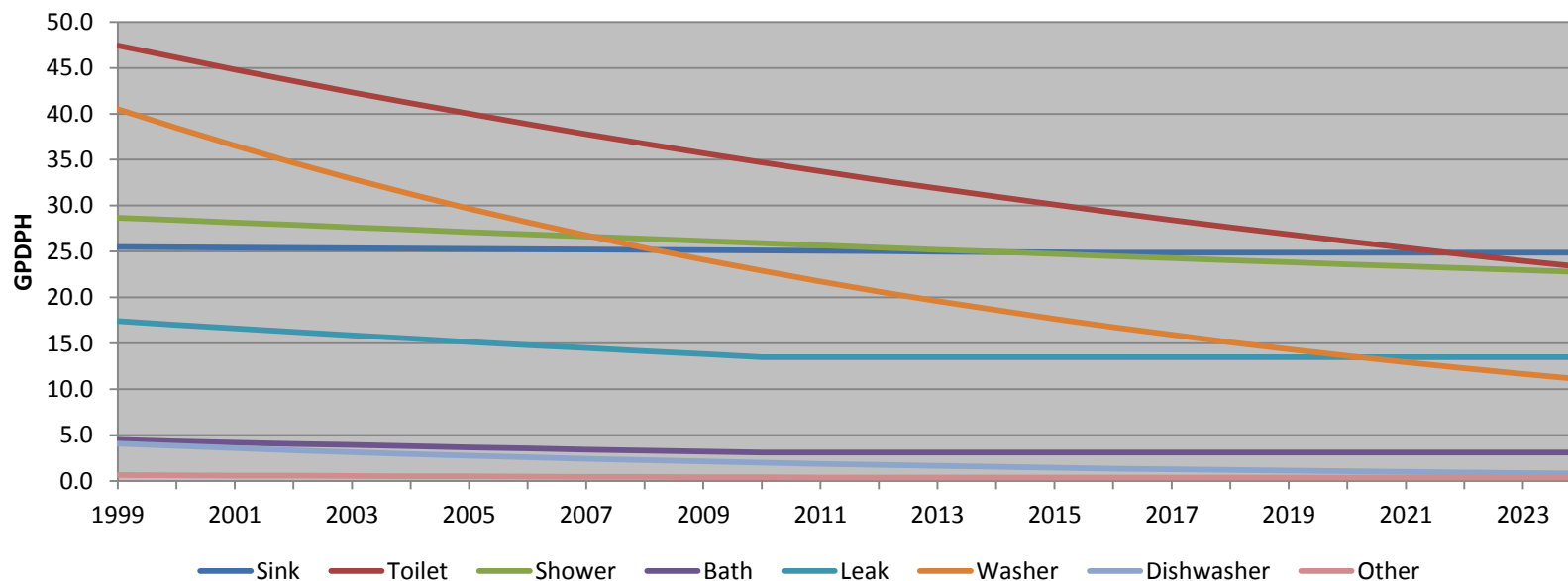
- We know we did not consume 479 gpdph
- Solving for Outdoor
  - Outdoor use in 2010 for Tacoma Water vs. the 2010 Sample was very different relative to indoor fixtures
  - *Total Household Use = Indoor + Outdoor +  $\epsilon$*
- Goal Seek Outdoor use to match with the remaining 1999 actual demand

	Average Daily Use per Household (gpdph)										
	Sink	Toilet	Shower	Bath	Leak	Washer	Dishwasher	Other	Indoor	Outdoor	Total
Tacoma 1999	25.5	47.4	28.7	4.5	17.4	40.5	4.1	0.6	168.8	72.2	241.0
Tacoma 2010	25.1	34.7	25.9	3.1	13.5	22.9	2.0	0.4	127.6	56.3	183.9

# Data: Modeling Fixtures

- **Not Modeled: Leaks & Other**
- **Slow decline: Bath, Sink, Shower**
  - Speculation: Larger investment, longer lasting, more fixtures
- **Fast decline: Toilet, Washer, Dishwasher**
  - Speculation: Standards, Incentives, Moving parts (washer, dishwasher) means more turnover, more technological upgrades

## Fixture Usage (gpdph)

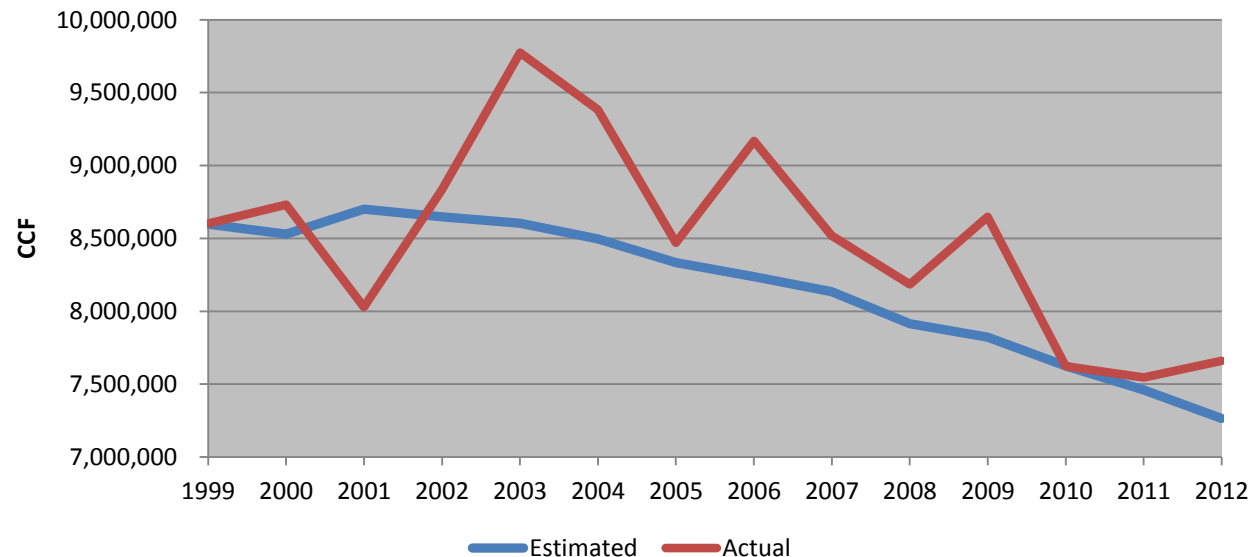


# Data: Model Comparison to History

- Both 1999 and 2010 were “Cold/Wet” years for Tacoma Water
  - The trend line follows the bottom percentiles
  - Hot/dry years are clearly over the estimate
- Outdoor use as percent share of total use approximately the same for 1999 and 2010
- MAPE = 4.98%

- Known hot years
  - 2003
  - 2006
  - 2009
  - 2012

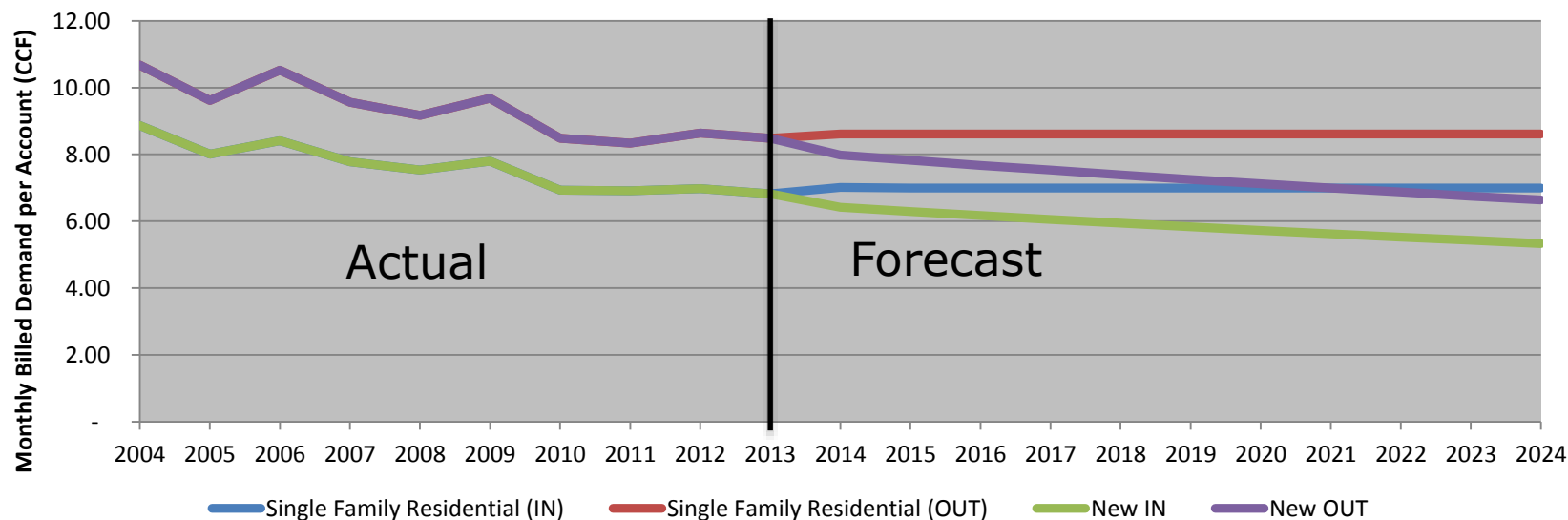
Single Family Residential - Est. Demand vs. Actual Demand (1999 - 2012)



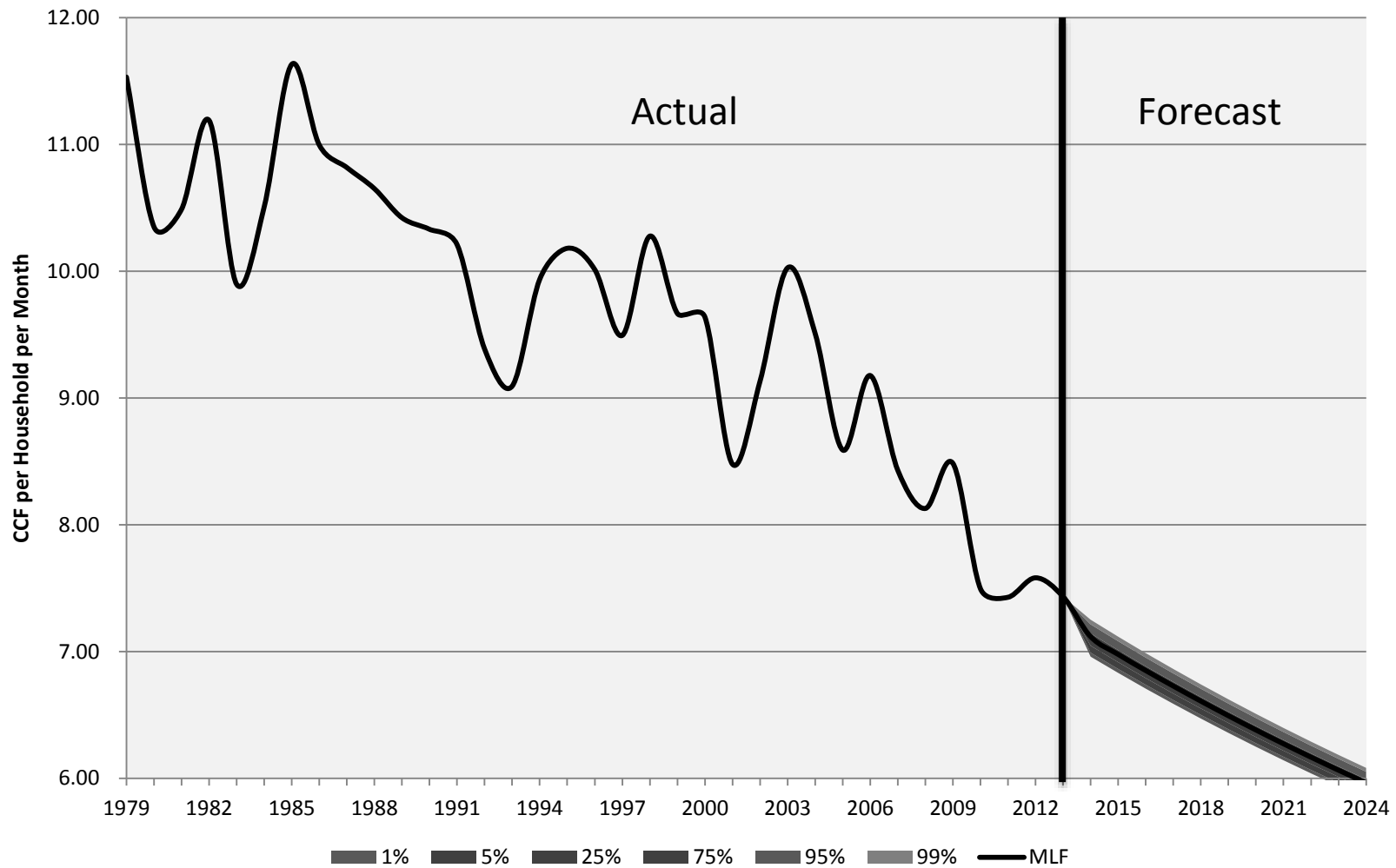
# Post-Processing the Demand Forecast

- Regression assumed normal weather
- We are applying a conservation year-over-year declines to the forecast
  - The conservation trend used data from two very cold/wet years
  - Interesting question: Would the trend look different during a hot/dry year or a “normal” year?

## Conservation's Effect on Residential Single Family's Forecasted Demand



## Total Residential Single Family Declining Trend Continues



- **Modeling**
  - Residential Single Family customers are not responding to hot/dry weather
    - Elective outdoor use along with indoor use is decreasing
    - Outdoor use during a hot year & peak day demands are falling
  - Good way to capture trend
- **There are a lot of assumptions → we know we can do better**
  - More data through AMI
    - Location specific demands – differences
    - Multi-family vs. single-family
    - Outdoor vs. indoor