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Disentangling Demand: Conservation Programs, Consumer Preferences, Rates, and Efficiency Standards

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MONTGOMERY
& ASSOCIATES
Water Resource Consultants

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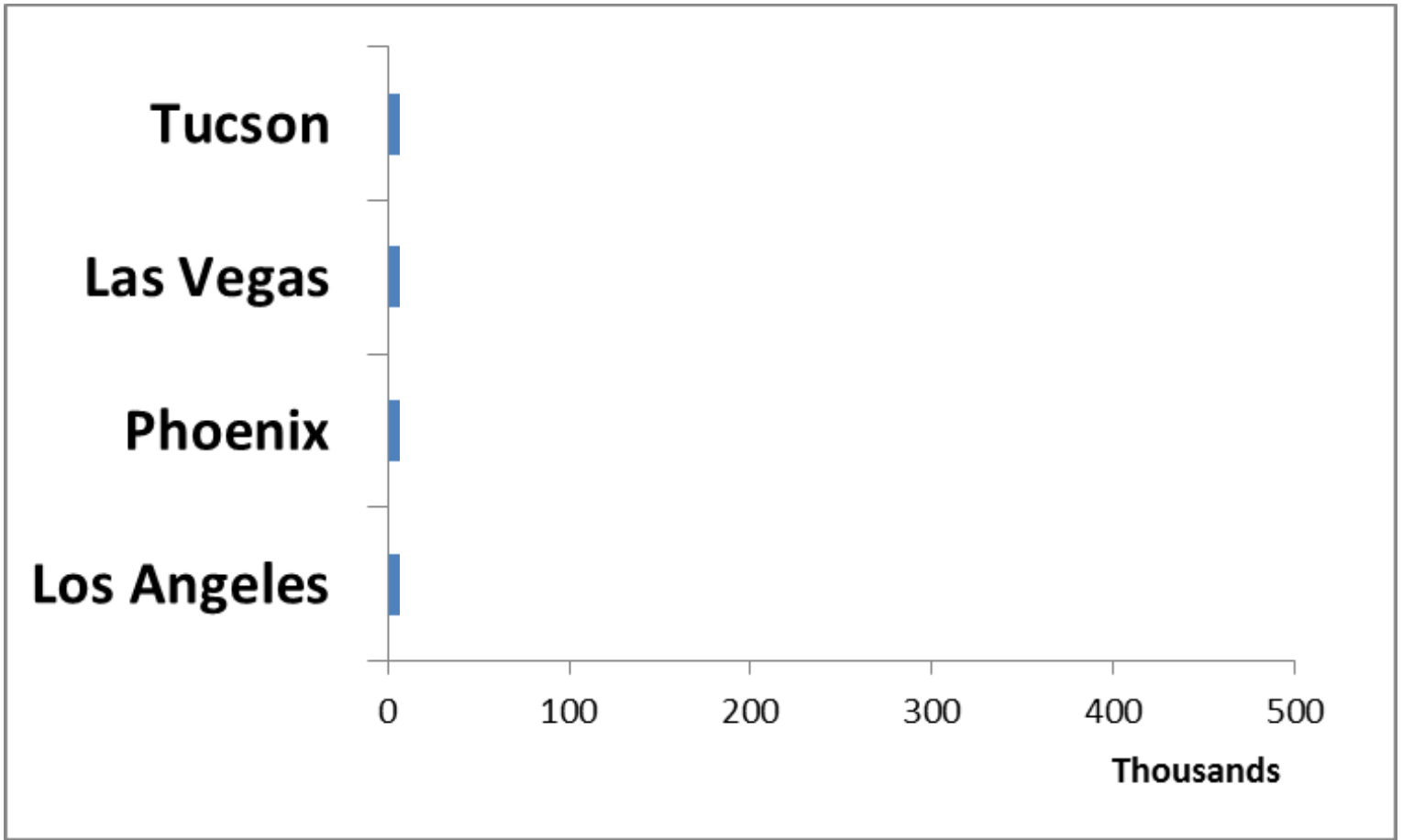
Las Vegas, Nevada

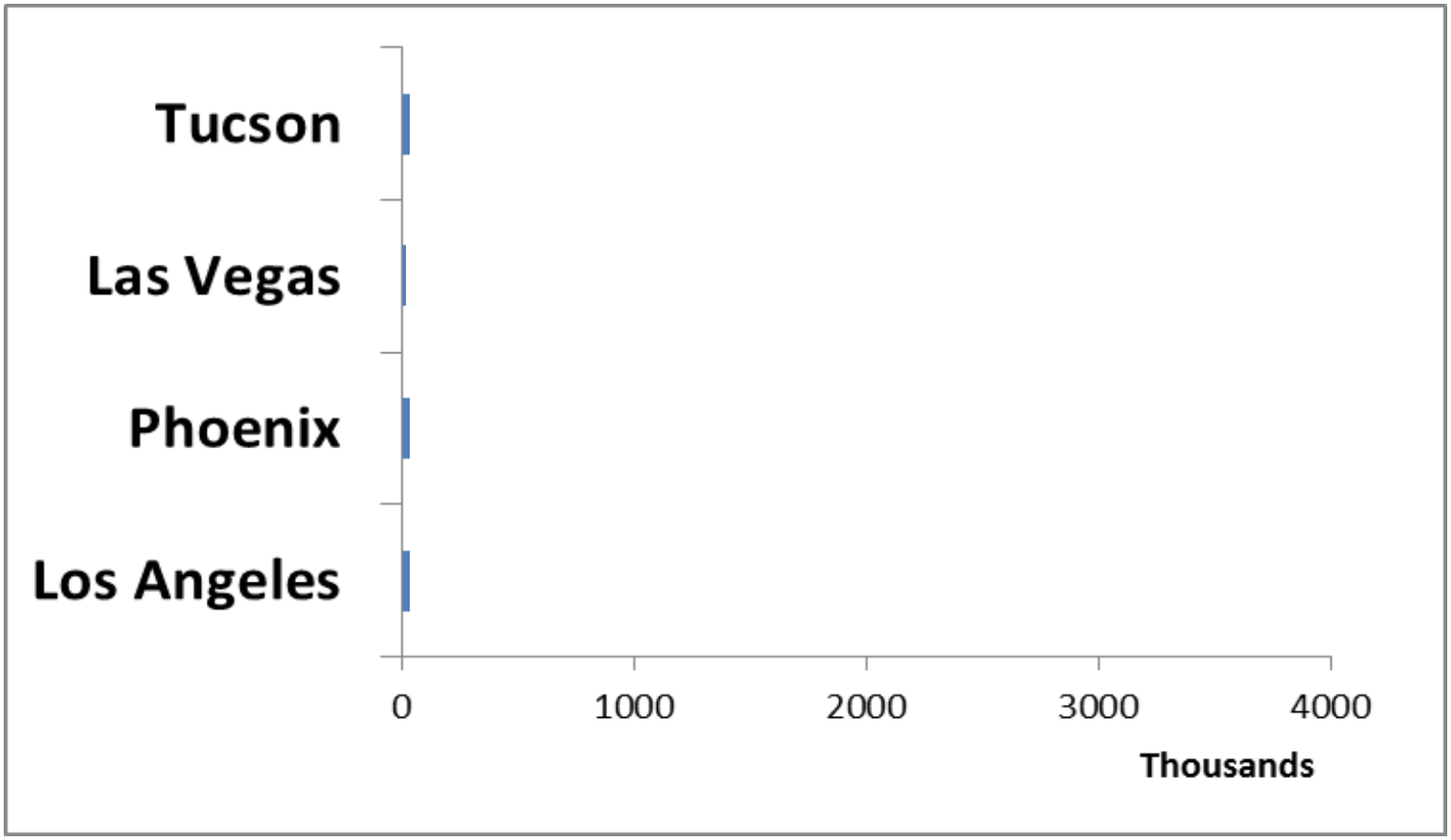
Western cities declared unsustainable

Google search results on “unsustainable” and names of rapidly growing western cities:

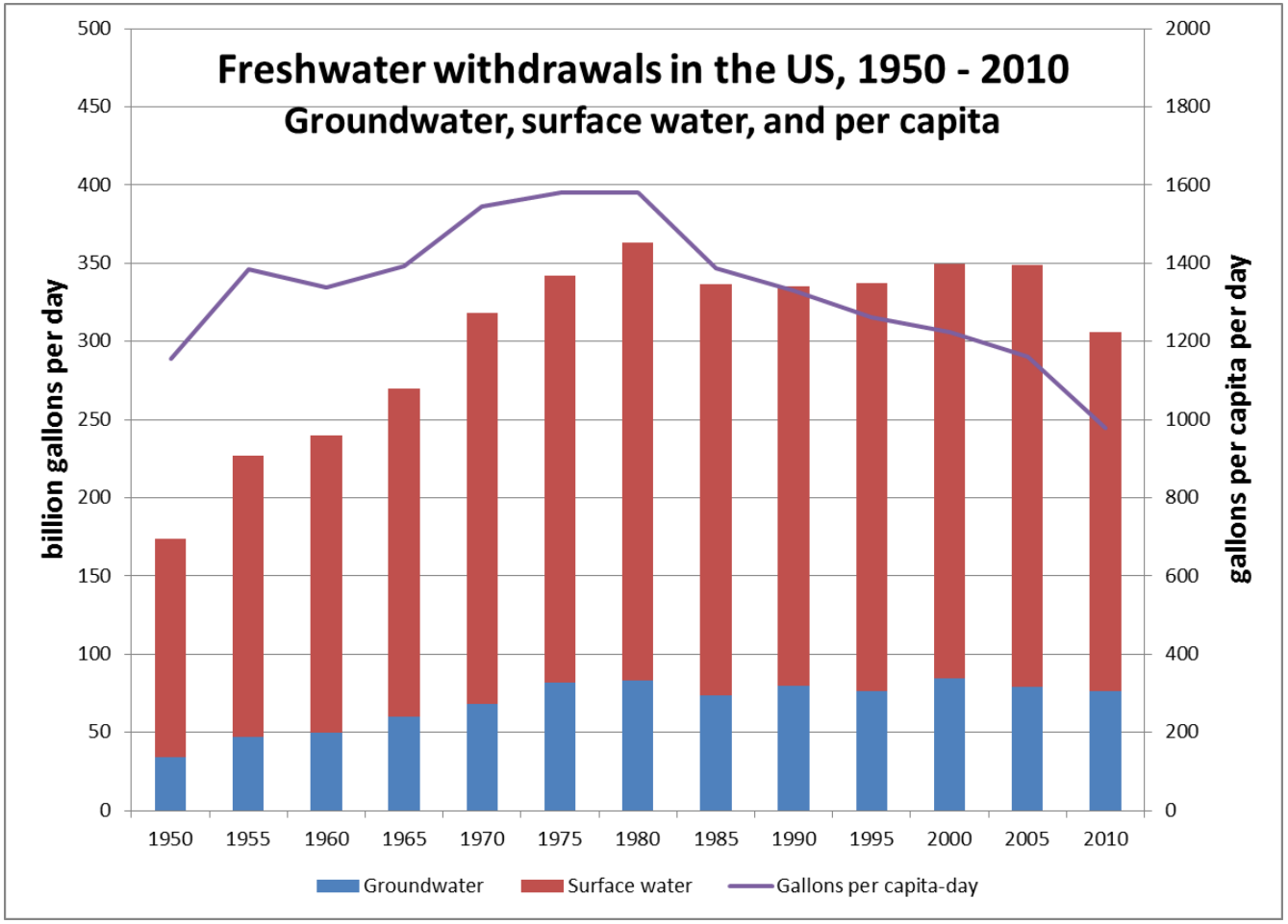


…as water supplies wither & demand grows

Google search on “growing water demand” and “western cities” produces 5.27 million hits



But U.S. water diversions peaked 35 years ago



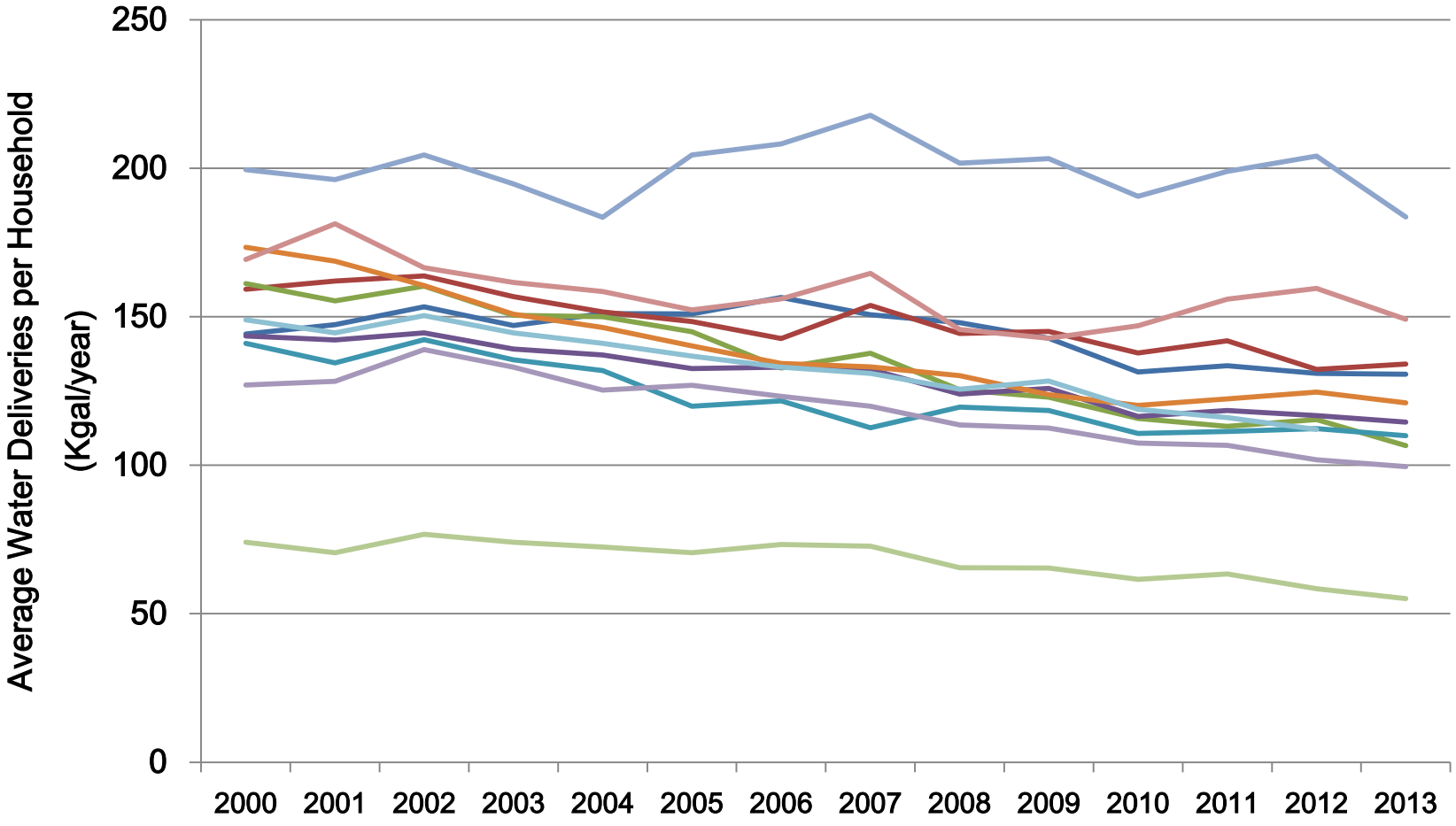
The declines are both wide and deep, occurring in municipal, industrial, agricultural, and power sectors, across the U.S.

Persistent assumptions and beliefs in municipal water planning include:

- Demand is tightly linked to population (*planners*)
- Raising prices and implementing increasing block rates are effective conservation tools (*economists*)
- Demand reductions caused by conservation programs are likely to be ephemeral and cannot be relied on (*engineers*)
  - Corollary 1 – better to have too much capacity than not enough
  - Corollary 2 – if too much capacity, you'll eventually grow into it
- Conservation programs are largely responsible for per-household reductions in demand (*you guys*)

Planning is rife with self-contradictory assumptions

Observed Declines in Demand



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Per-capita and per-household demand is falling faster than population is growing

- Tucson Water deliveries in 2015 were less than in 1986, despite a 65% increase in customers
- Albuquerque-Bernalillo County deliveries in 2014 were less than in 1983 despite a 70% increase in population
- Similar trends are seen in Las Vegas, Los Angeles, Phoenix…

Denial of long-term declines in demand leads to “dog-hair demand curves”

Dog-hair demand curves result from:

- Tying demand to population projections
- Being overly conservative
- Over-reacting to short-term events
- Ignoring or misinterpreting long-term trends

Challenges of declining municipal demand

Unanticipated declines in municipal water demand have created issues, including:

Fiscal Consequences
- revenues drop more than expenses
- conservation-oriented rate designs exacerbate the problem
- budgeting uncertainties

Operational Issues
- reuse of reclaimed water
- longer “water age” impacts residual disinfectant levels and disinfection by-products
- uncertainties as to available unused system capacity for wastewater plants

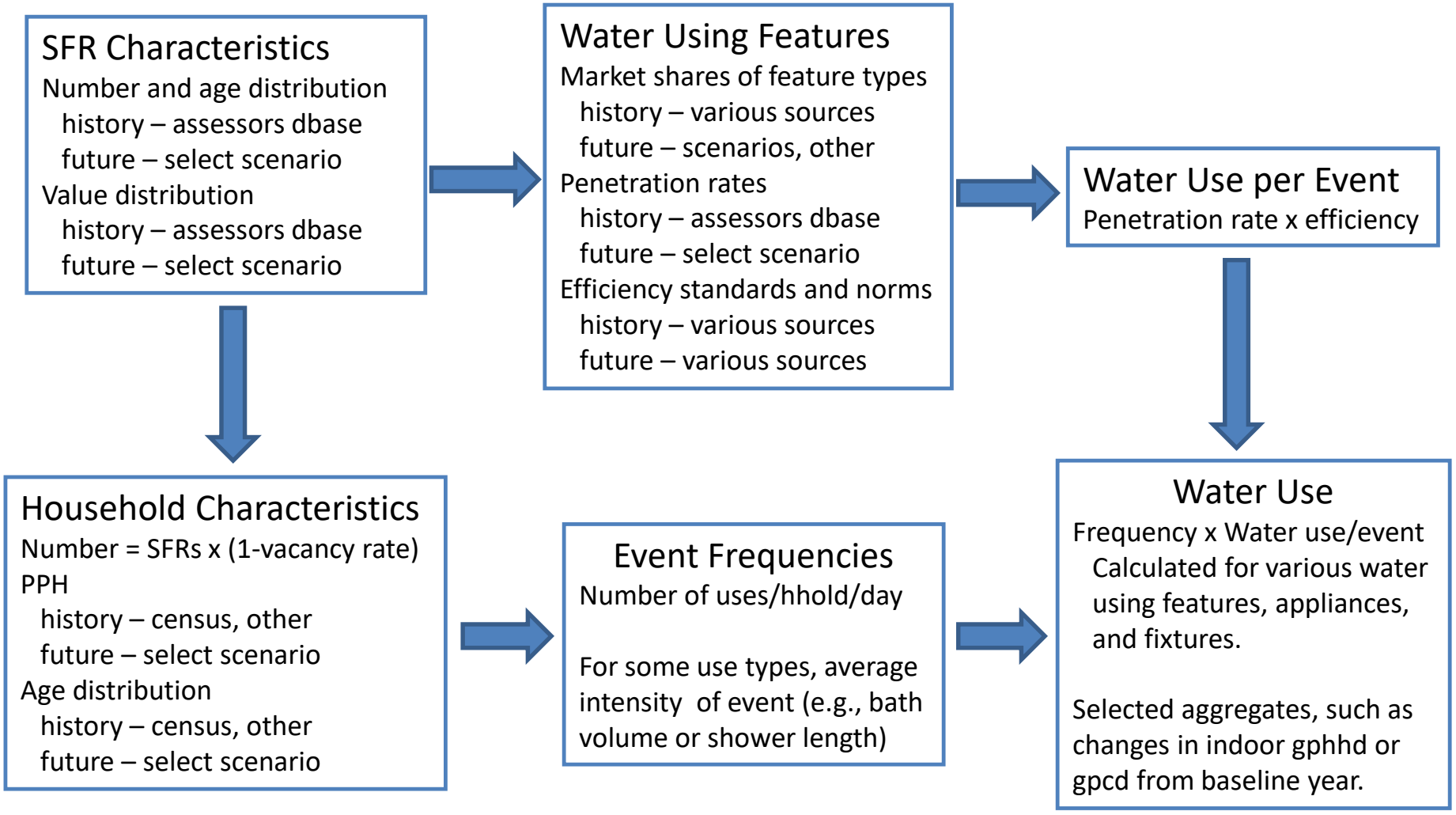
Planning Challenges
- optimal timing of capital improvements
- acquisition of new supplies
- rate setting
- design of water conservation programs

Public Perception Issues
- water conservation blamed for rate hikes
- people feel they are being punished for conserving

Dynamic simulation models of residential demand were developed for a dozen municipal areas in Arizona:

- Chandler
- Gilbert
- Glendale
- CWC of Green Valley
- Maricopa County
- Mesa
- Metro Water
- Peoria
- Pima County
- Scottsdale
- Tempe
- Tucson

Model Structure for Residential Demand Trends



Dynamic simulation allows models to incorporate deep and complex linkages

Selecting an economic scenario…

changes the rate of housing construction

and the distribution of new homes by value

which affect percent of new homes with pools

and the average size of pools

both of which affect outdoor water demand

and more linkages…

New SFRs have larger households with more pre-adults…

which changes overall household socio-demographics,

and frequency of use of appliances & fixtures

which affects all facets of indoor demand

…and still more linkages.

Selecting an economic scenario also changes…

the rate of sales of existing houses

and the distribution of existing home sales by value

which affect home remodeling

which affects indoor water demand

Everything affects everything, and these models attempt to capture that.

Model findings challenge old assumptions with new realities:

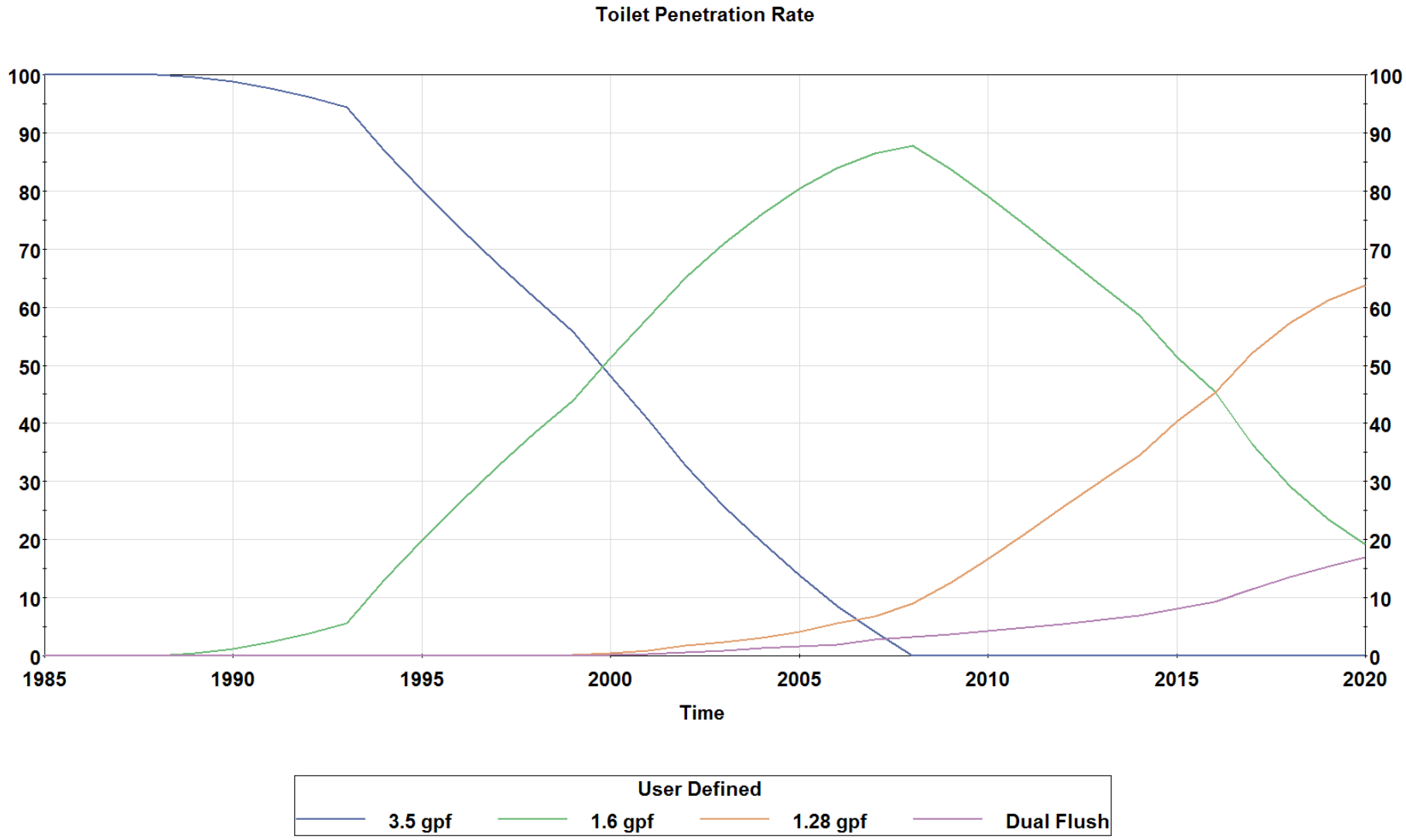
Most of the decreases in household demand results from:

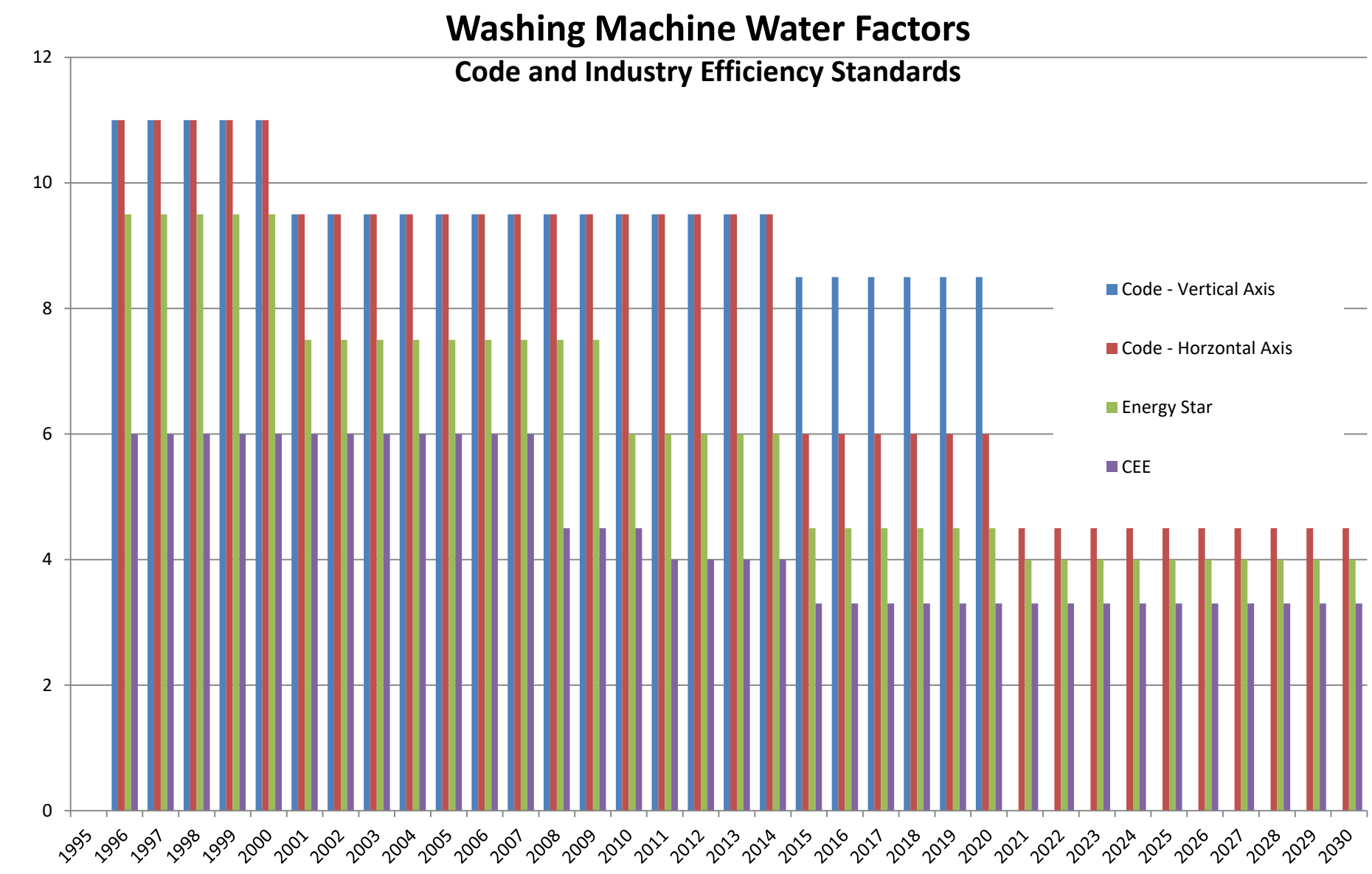
- Routine replacement of appliances and fixtures with more water-efficient models
- Changing consumer tastes and preferences in outdoor living spaces
- Construction of highly water-efficient new homes

In most instances, local conservation programs have less short-term impact on demand than these factors.

But they often receive much of the credit for declining demand or the blame for rate hikes.

Toilets: The Impact of Changing Technology




Washing Machine Water Factors
Code and Industry Efficiency Standards
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Code - Horzontal Axis
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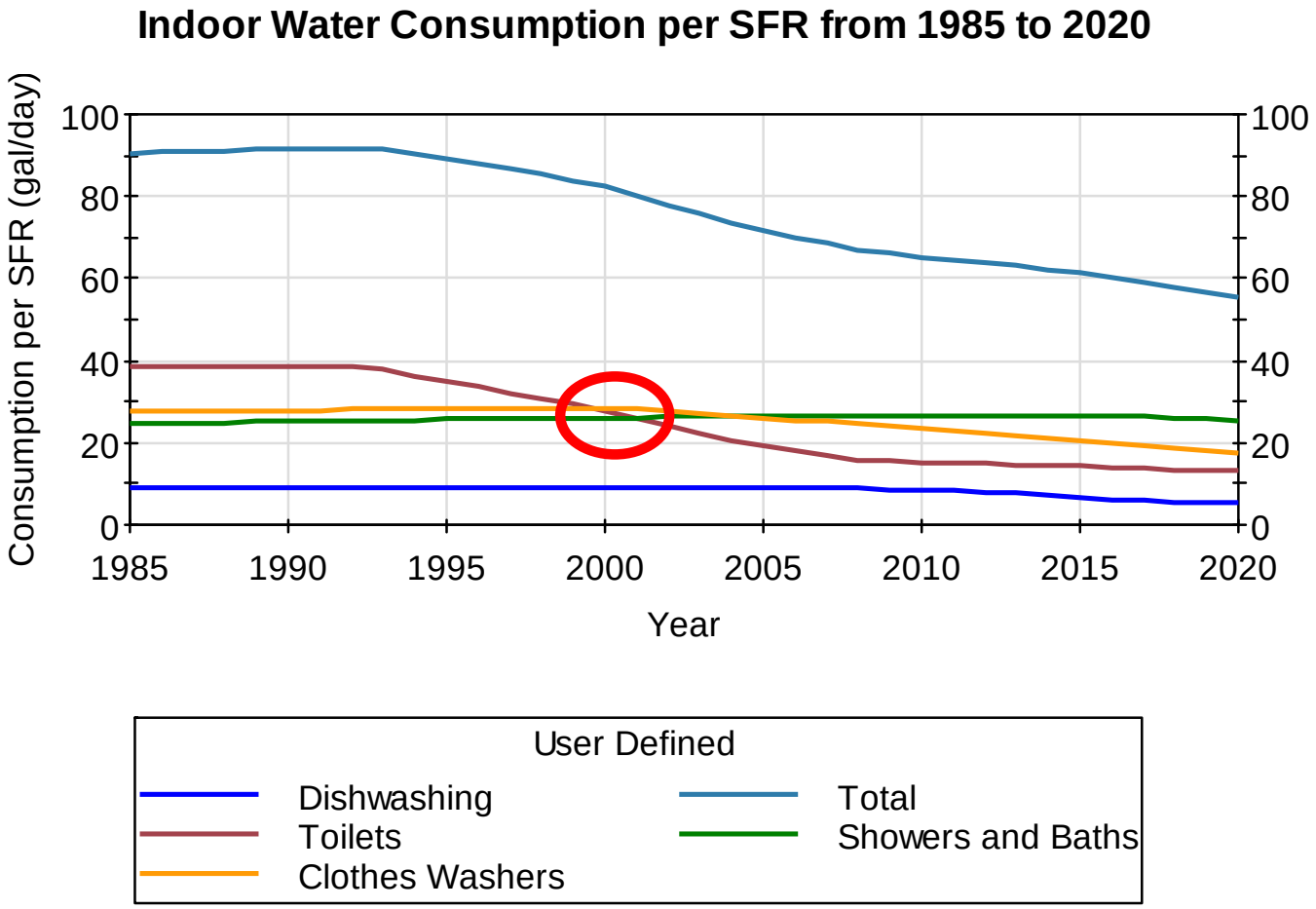
Indoor Water Demand



Turf irrigation can be reduced by:

- Abandonment
- Reductions in area
- Replacement with xeriscapes, drought-tolerant plant species
- Restrictions in new housing construction
- Replacement with artificial turf

Four turf “crops” were analyzed:

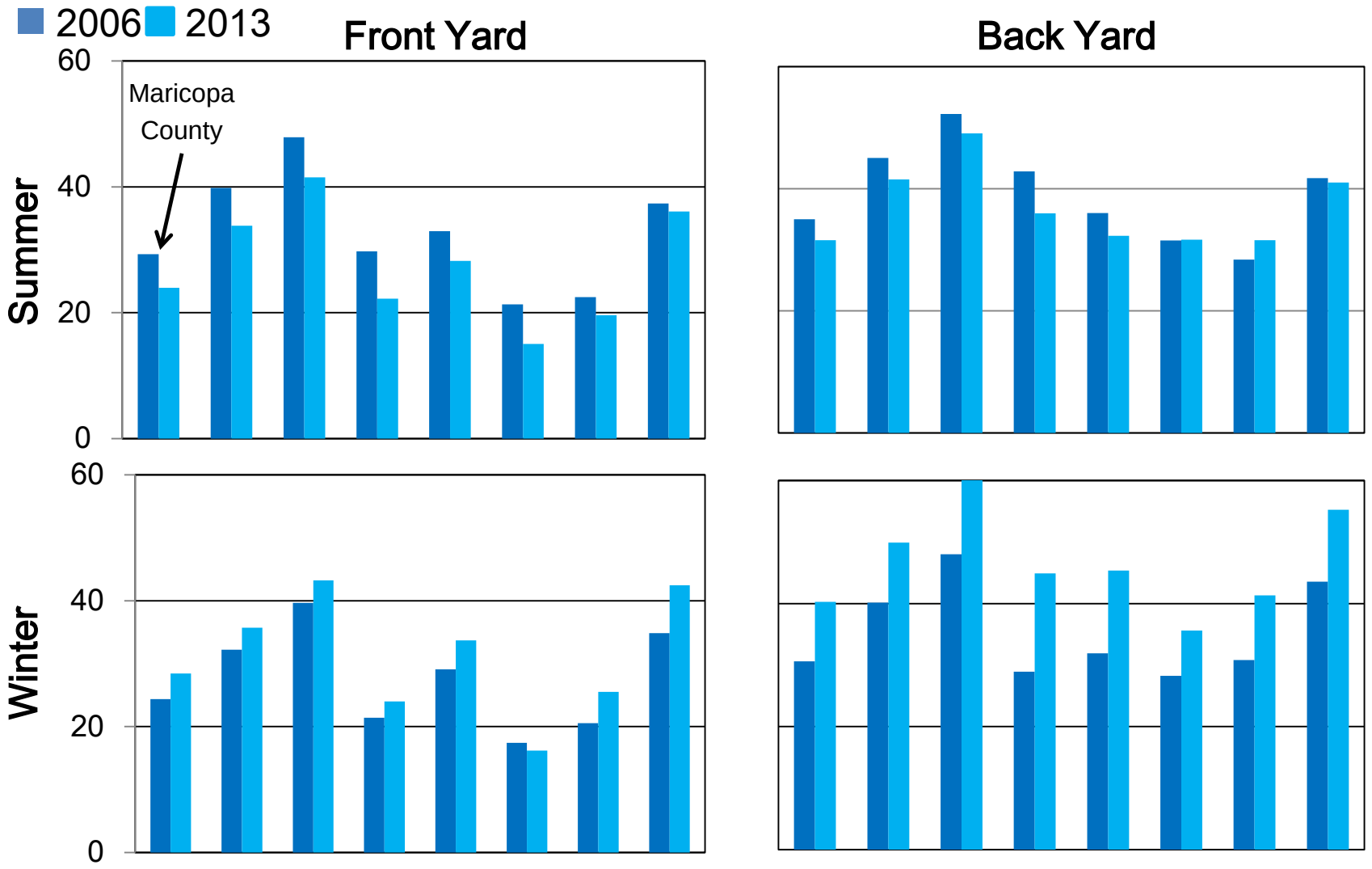
Front yard summer turf

Front yard winter Rye turf

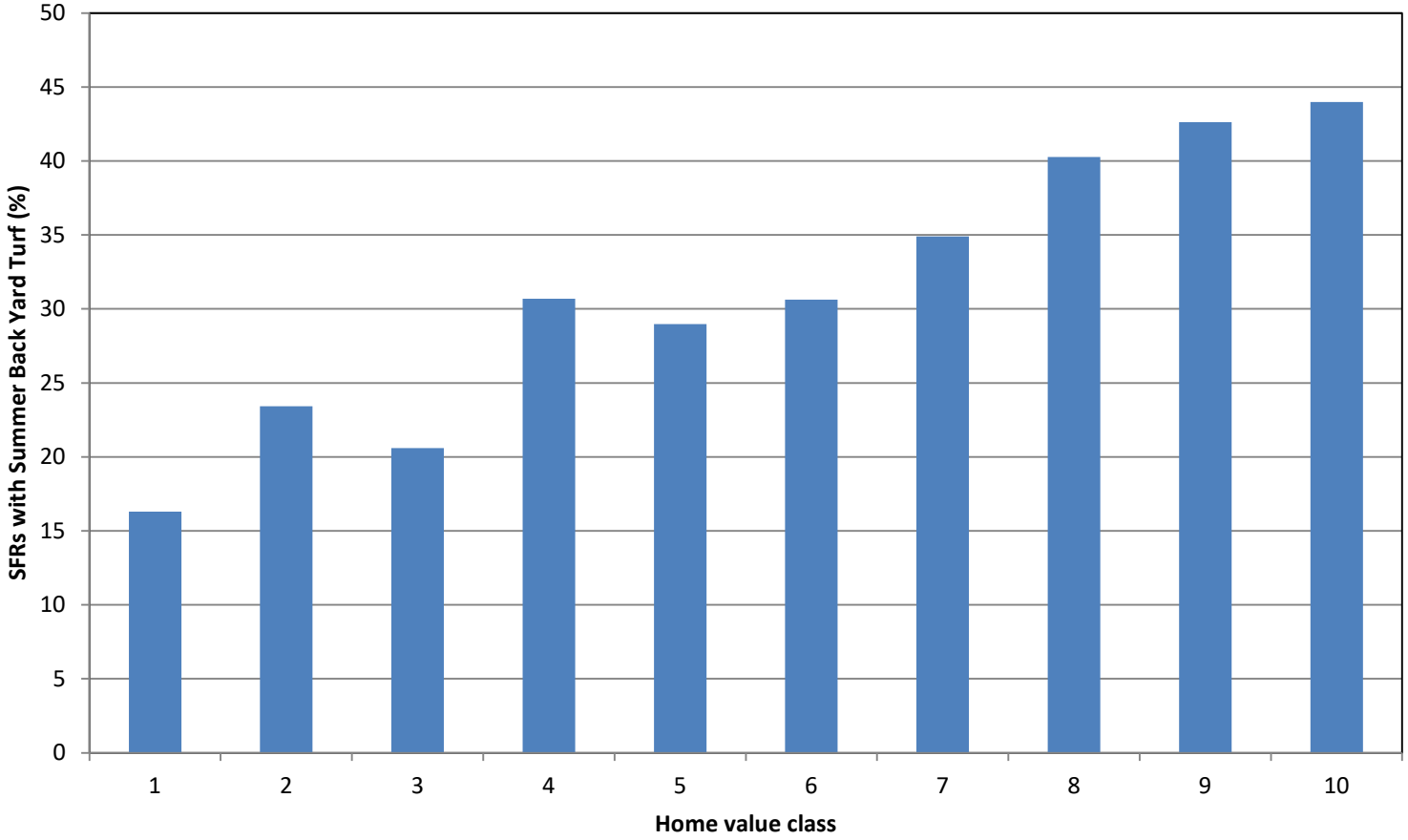
Back yard summer turf

Back yard winter Rye turf

Changing Turf Preferences

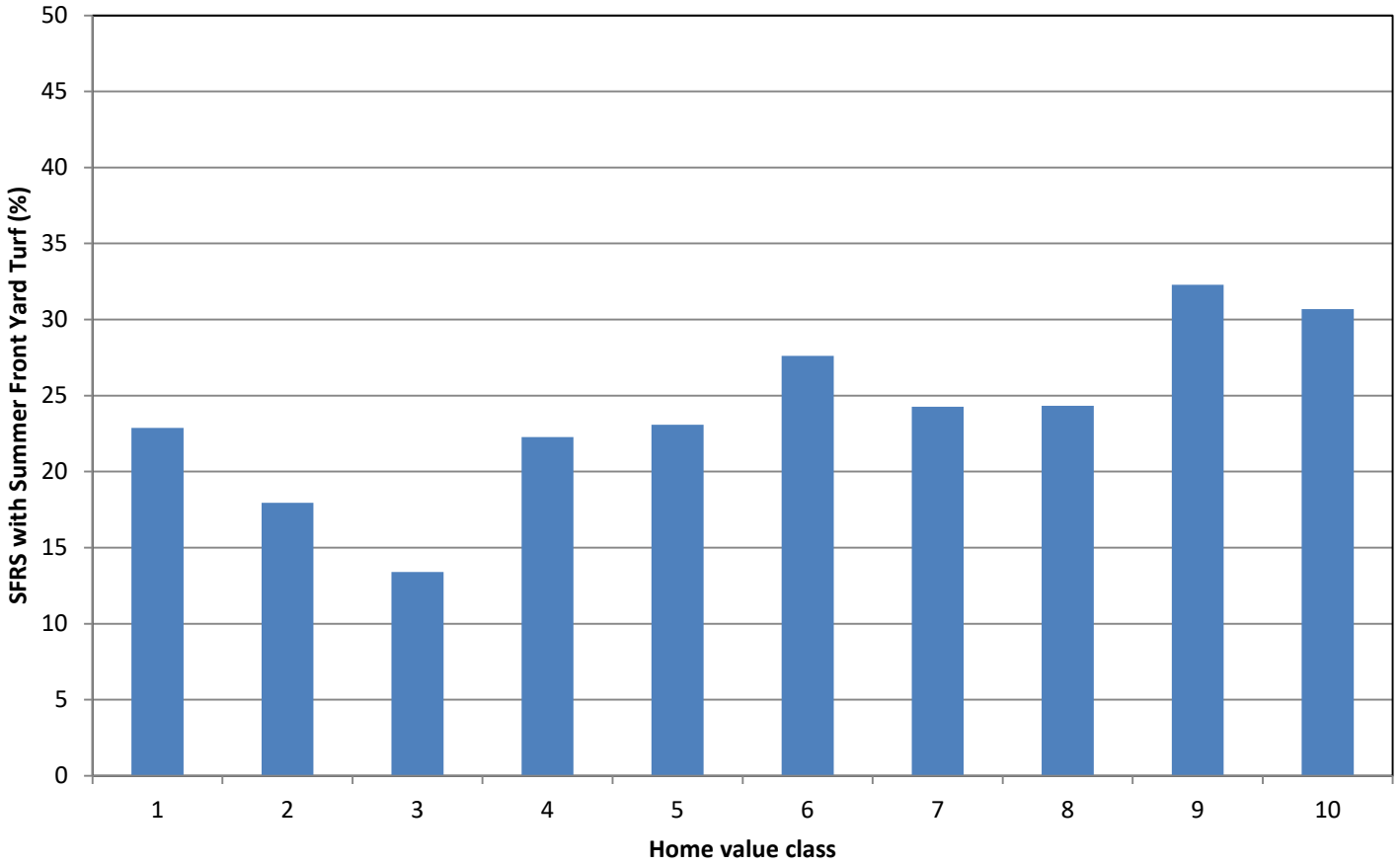


Back yard summer turf is positively correlated to home value



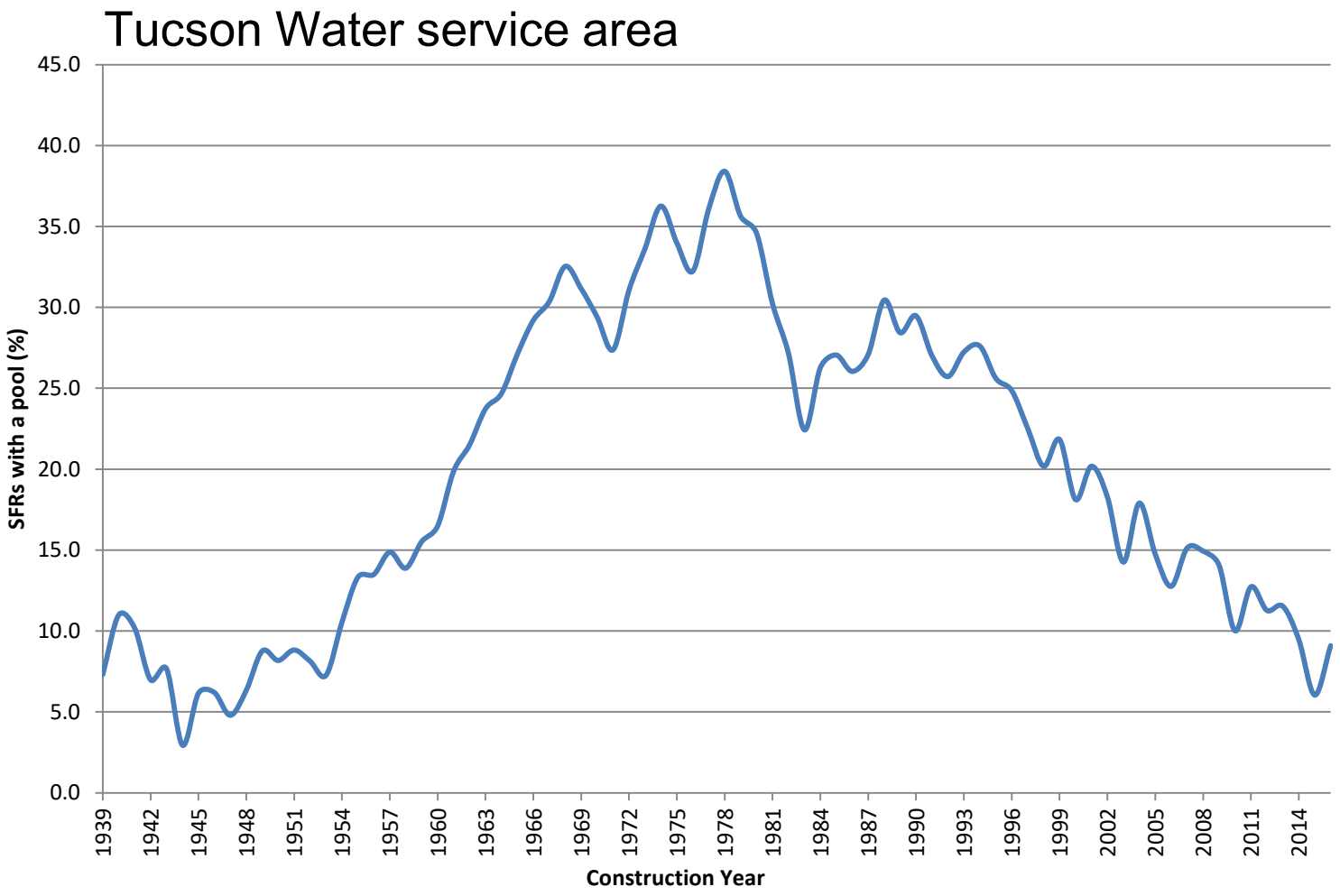
Penetration rates for irrigated summer turf in back yards as a function of home value class

Front yard summer turf is not strongly or simply related to home value

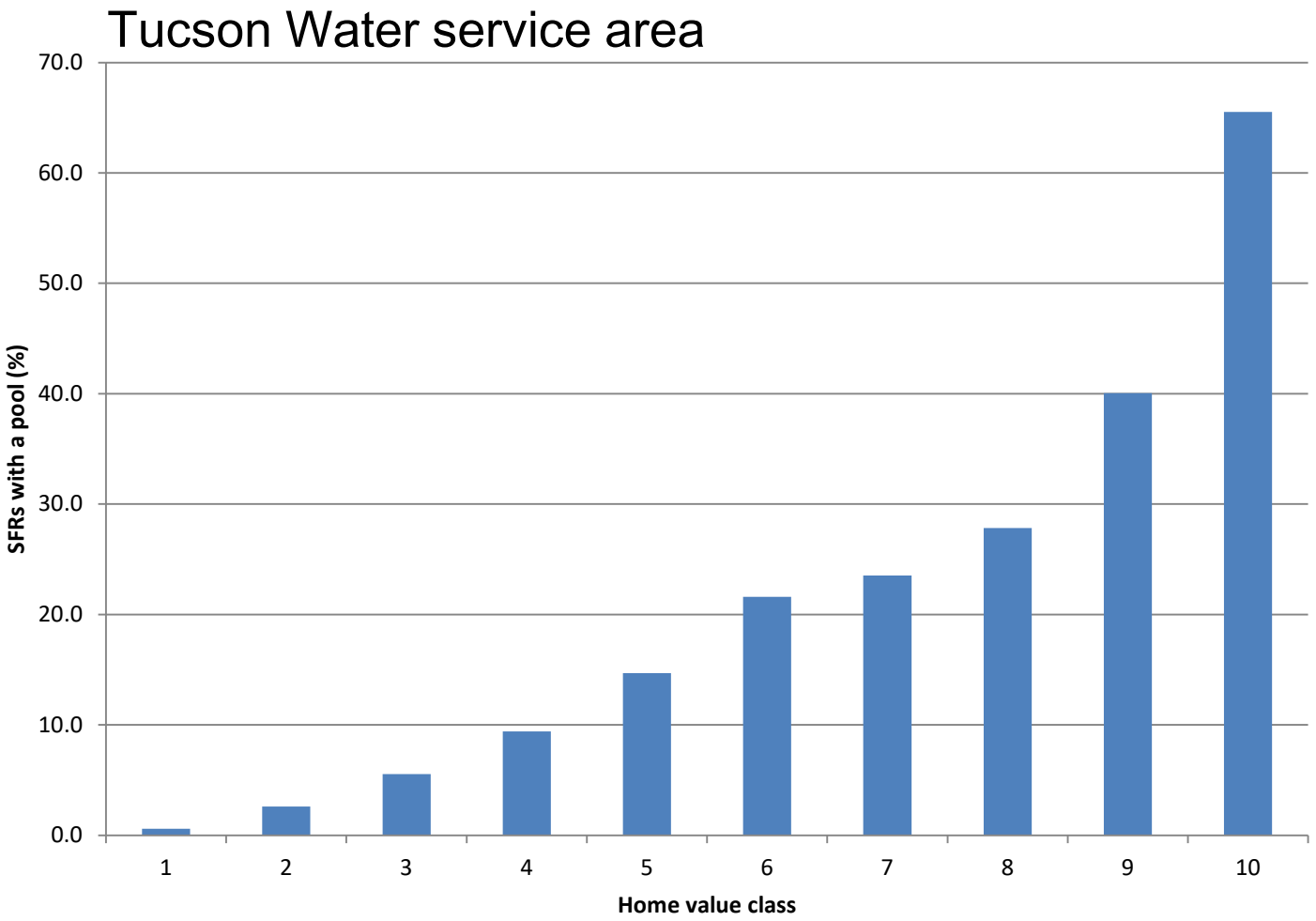


Penetration rates for irrigated summer turf in front yards as a function of home value class

New homes in Tucson are only one-fifth as likely to have a pool as homes built in late ’70s

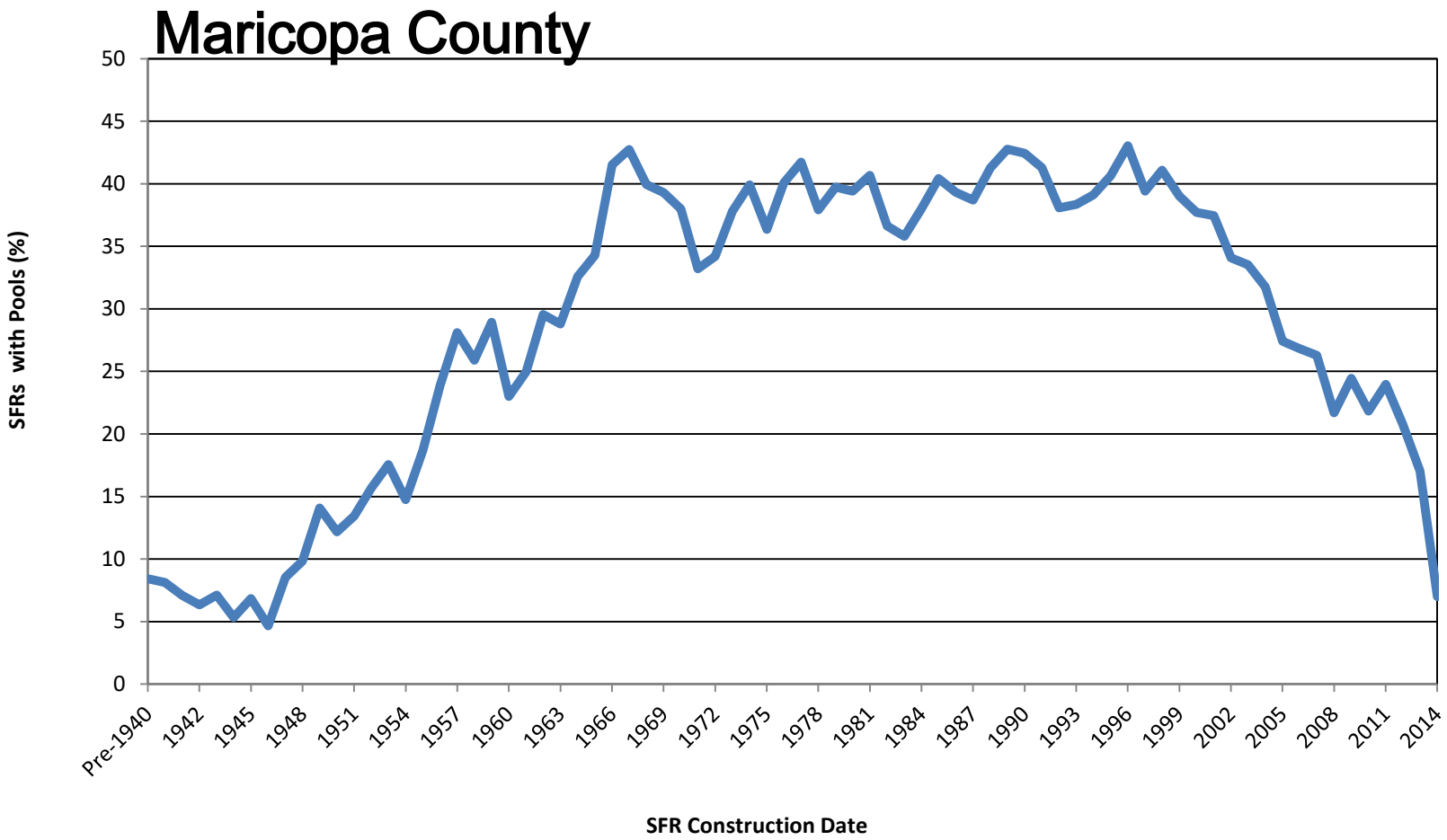


Home value is a more important factor in pool penetration rates than in the past



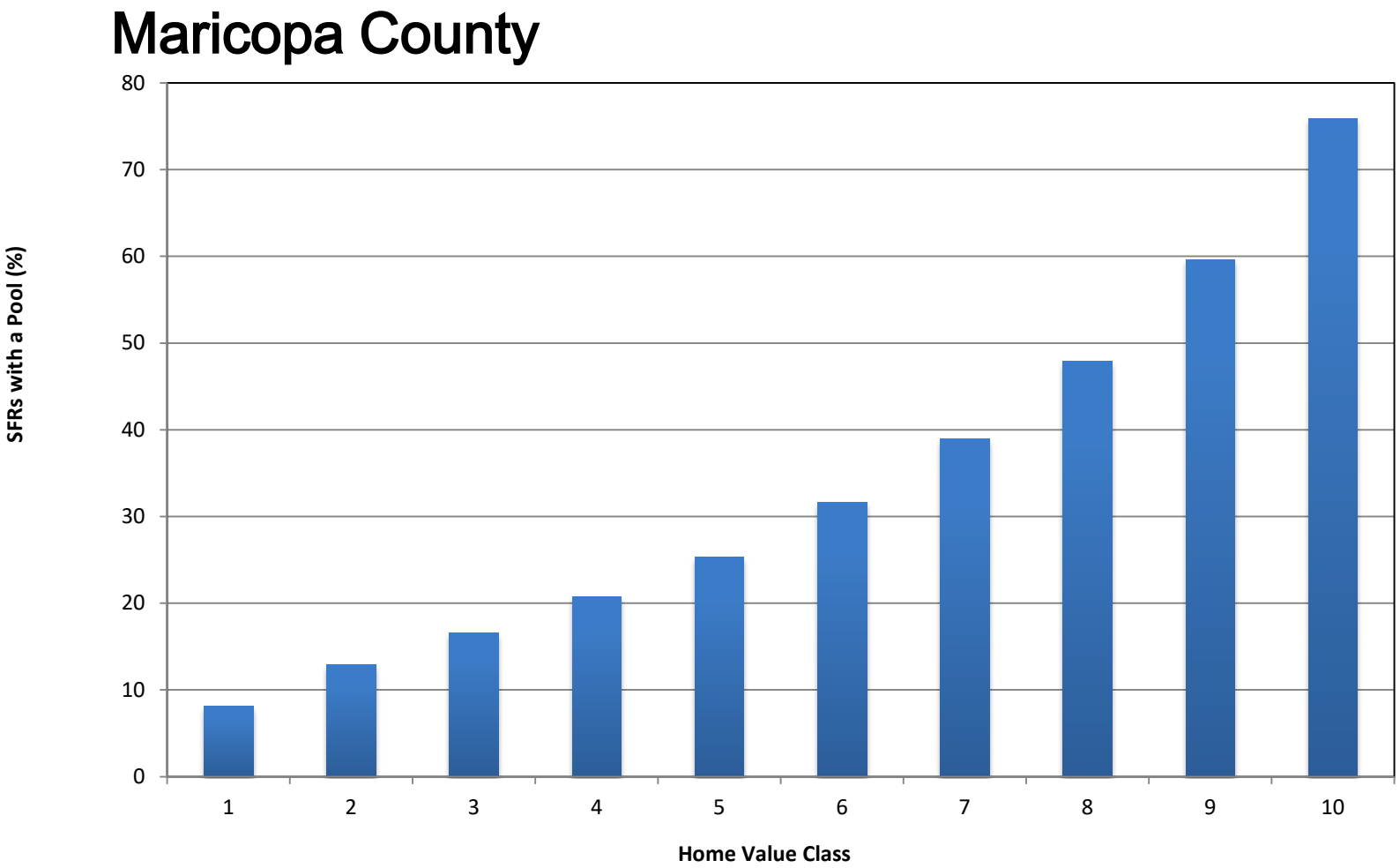
Half of all pools are in the top 20% of homes by market value

More recent but precipitious decline in pool popularity seen in Maricopa County as well



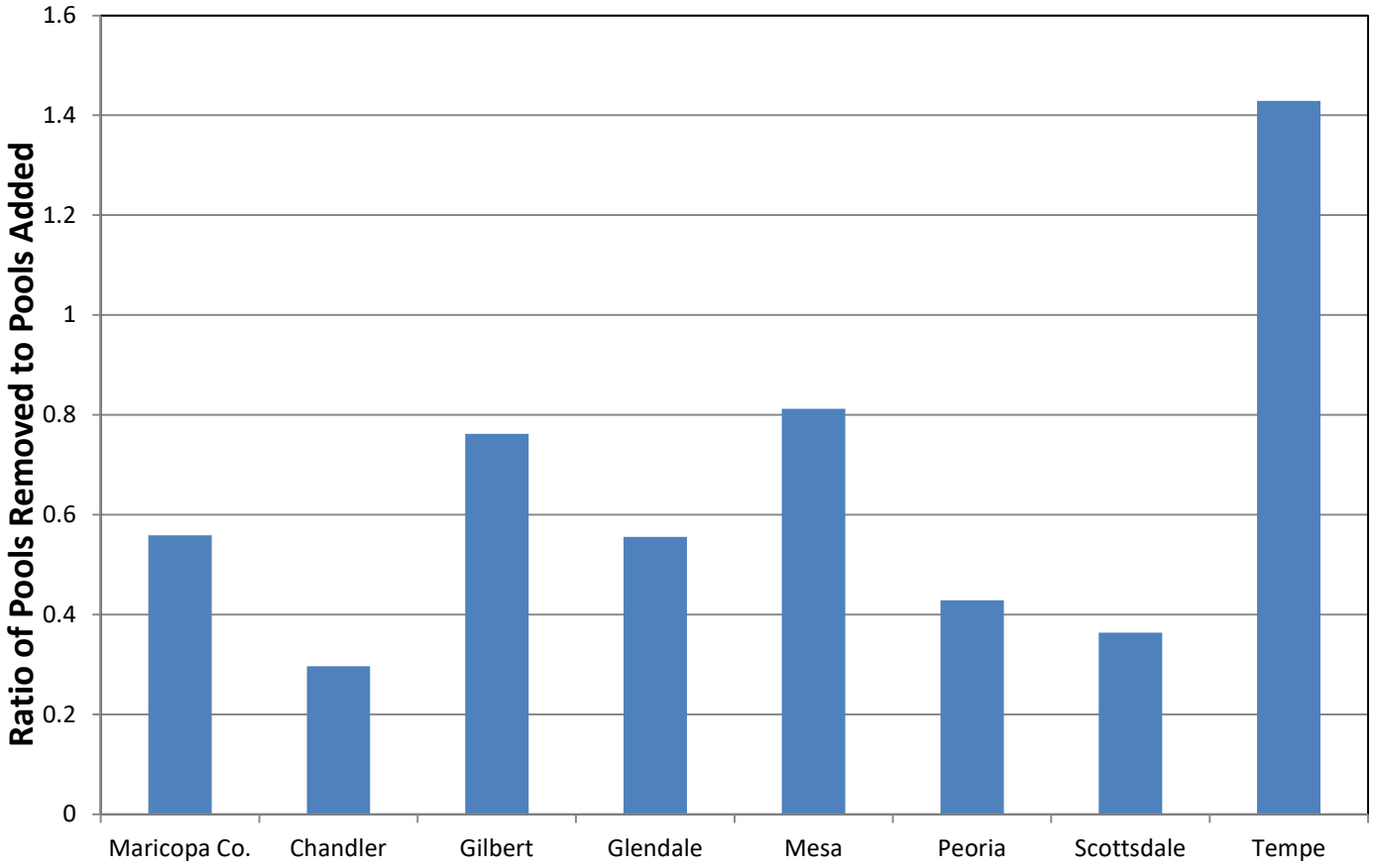
39% of SFRs have a pool, but their popularity has been declining steeply for over 15 years.

Pools are strongly correlated with home value



Percent SFRs with a pool as a function of home value class

Pool removal rates are approaching pool construction rates…



… even thought conservation programs aimed at encouraging pool removals are very rare.

Typical pools – past, present, future

Backyard pools are becoming:

- less popular
- more associated with higher-valued homes
- more used by adults for exercise, not by families for recreation
- increasingly likely to be removed
- smaller in surface area (in some areas)

Evidence suggests PPH no longer declining:

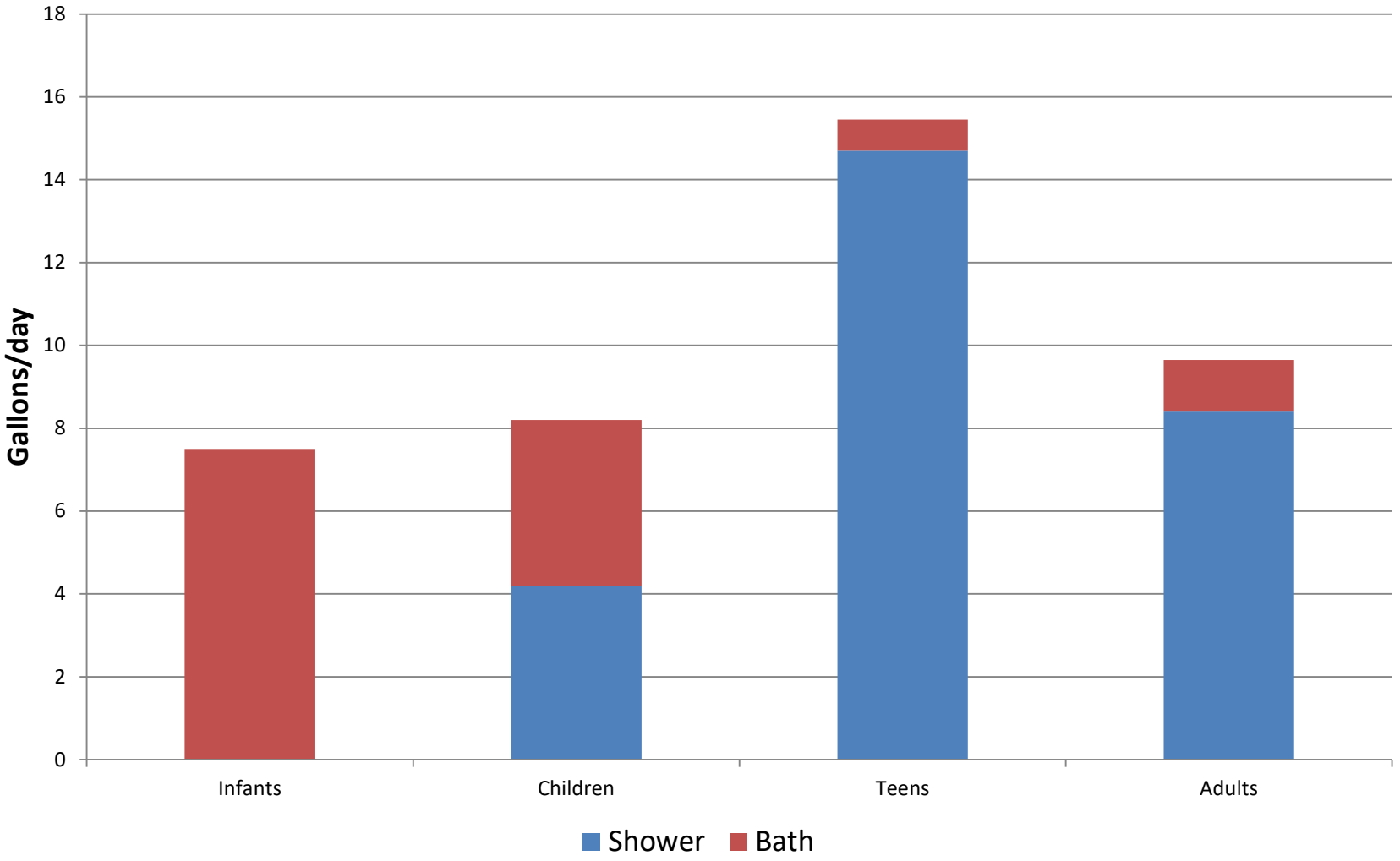
- Boomerang kids
- Growing percentage of 3-generation households
- More alternate household living arrangements
- Building industry responding with “home within a home”

But households are still changing

- Fewer infants, children and teens
- More 1-adult households, including with children
- More retirees and snowbirds
- In general, a graying population

These trends are affecting the frequency of water using activities and explain many cross-sectional differences in demand

Shower & bath usage by age cohort

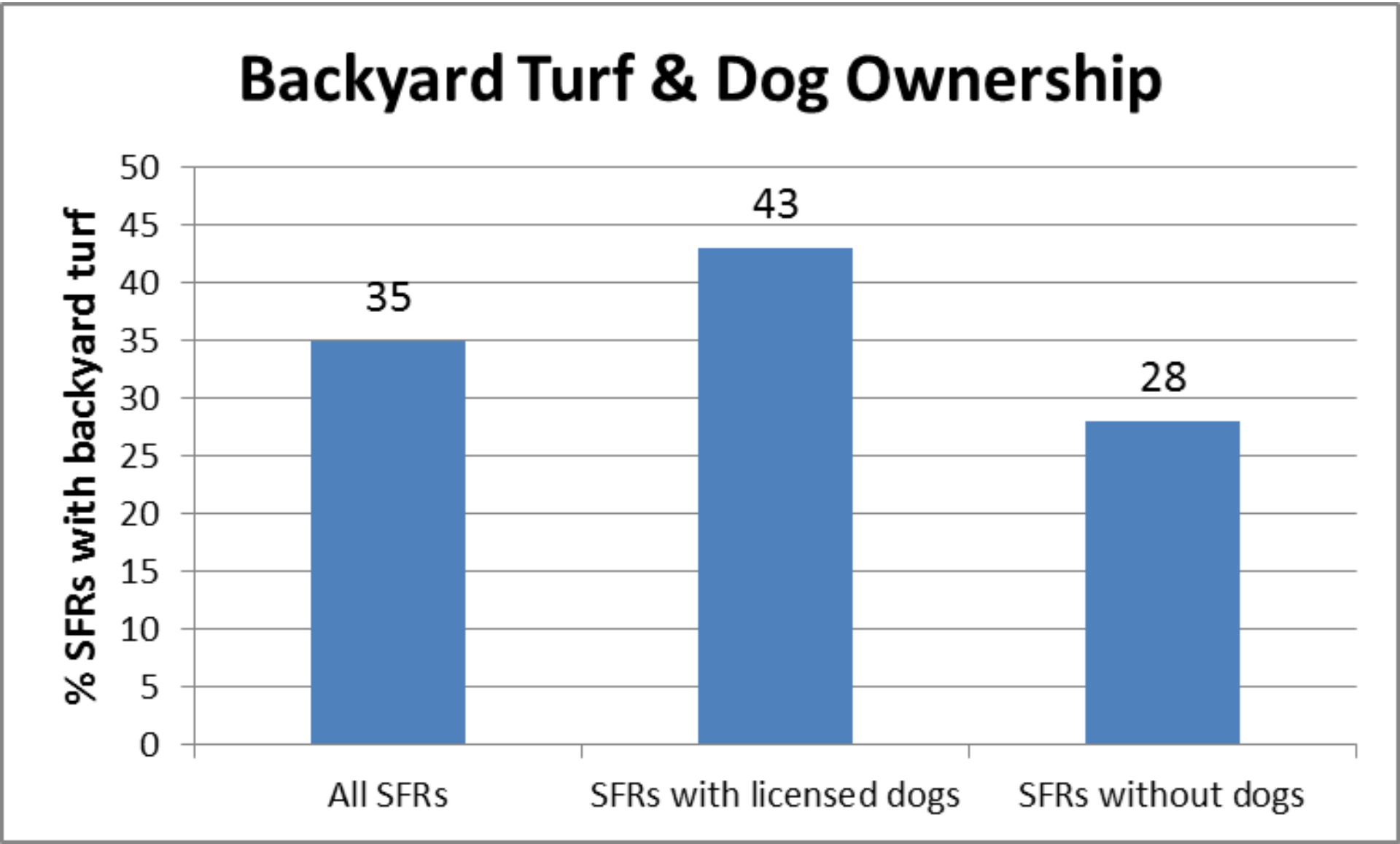


Changing face of the American family

Only 33% of households have children, and the figure is declining.

About 45% of households have at least one dog.

Dog ownership & backyard turf are correlated



How low could it go?

There is a long history of underestimating the capacity of new technology to further decrease municipal water demand.

Examples:

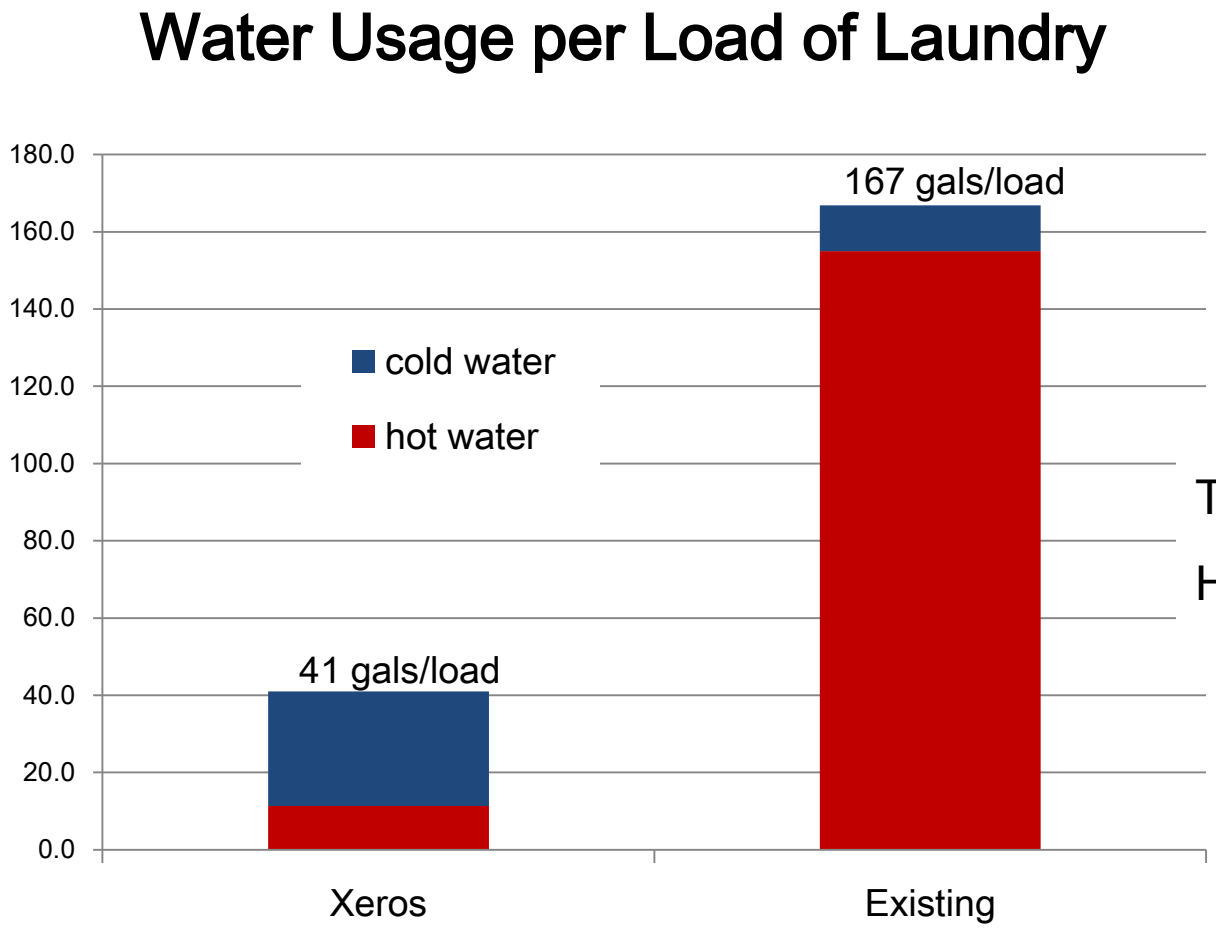
- Impacts of voluntary standards in neighboring states
- Swimming pool removals
- Sub-1.28 gpf toilets
- Sub-2.0 gpm shower heads
- Artificial turf
- Dishwashers & sink usage
- Polymer bead clothes washers

Polymer bead clothes washer claims:

Xeros 65-lb. washer

- Reduces water use by up to 80%
- Reduces hot water use almost entirely
- Reduces use of chemicals by 50%
- Reduces drying time and energy
- Prolongs life of clothing
- Provides a superior cleaning

Preliminary results of pilot study



Total water use down 75.4%

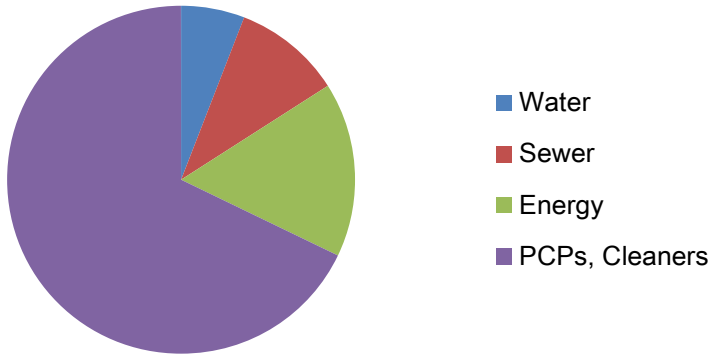
Hot water use down 92.7%

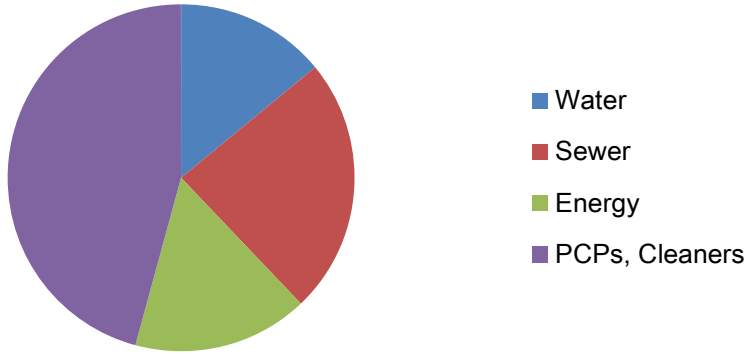
Some thoughts on price, costs, and demand

Price increases  Demand falls

The real cost of indoor water uses - showers

	QUANTITY	COST	PERCENT TOTAL COST
SHOWER-maximum products			
Water	15.8 gal	$0.063	5.0
Sewer	15.8 gal	$0.108	8.5
Energy	2.06 kWh	$0.211	16.6
Shampoo	0.6 fl oz	$0.450	35.4
Conditioner	0.3 fl oz	$0.225	17.7
Body Wash	0.3 fl oz	$0.096	7.6
Moisturizer	0.2 fl oz	$0.118	9.3





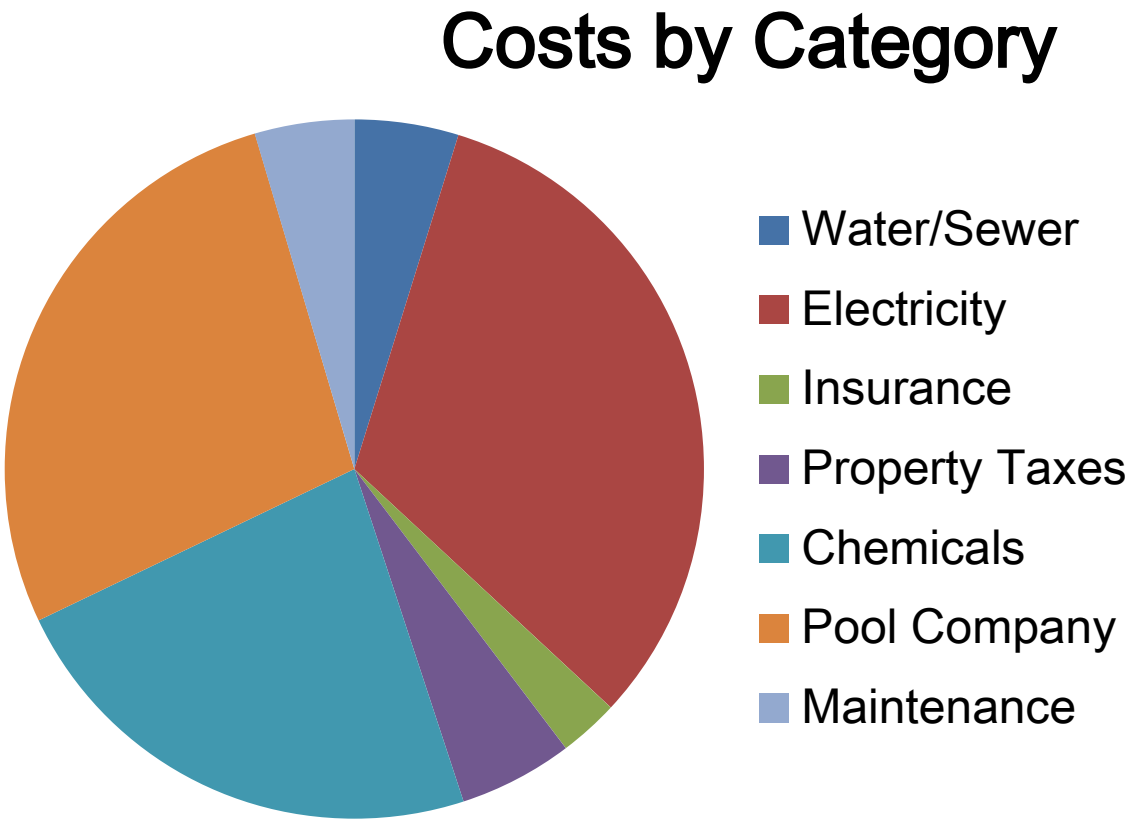
Between 6% & 14% of indoor water use costs are for the water

Diverse benefits of pool removal

Pecuniary benefits include lower:

- water and sewer bills
- electric bills
- homeowner's insurance
- property taxes
- chemicals costs
- pool service company expenses
- maintenance and repairs

Annual total costs of maintaining a pool



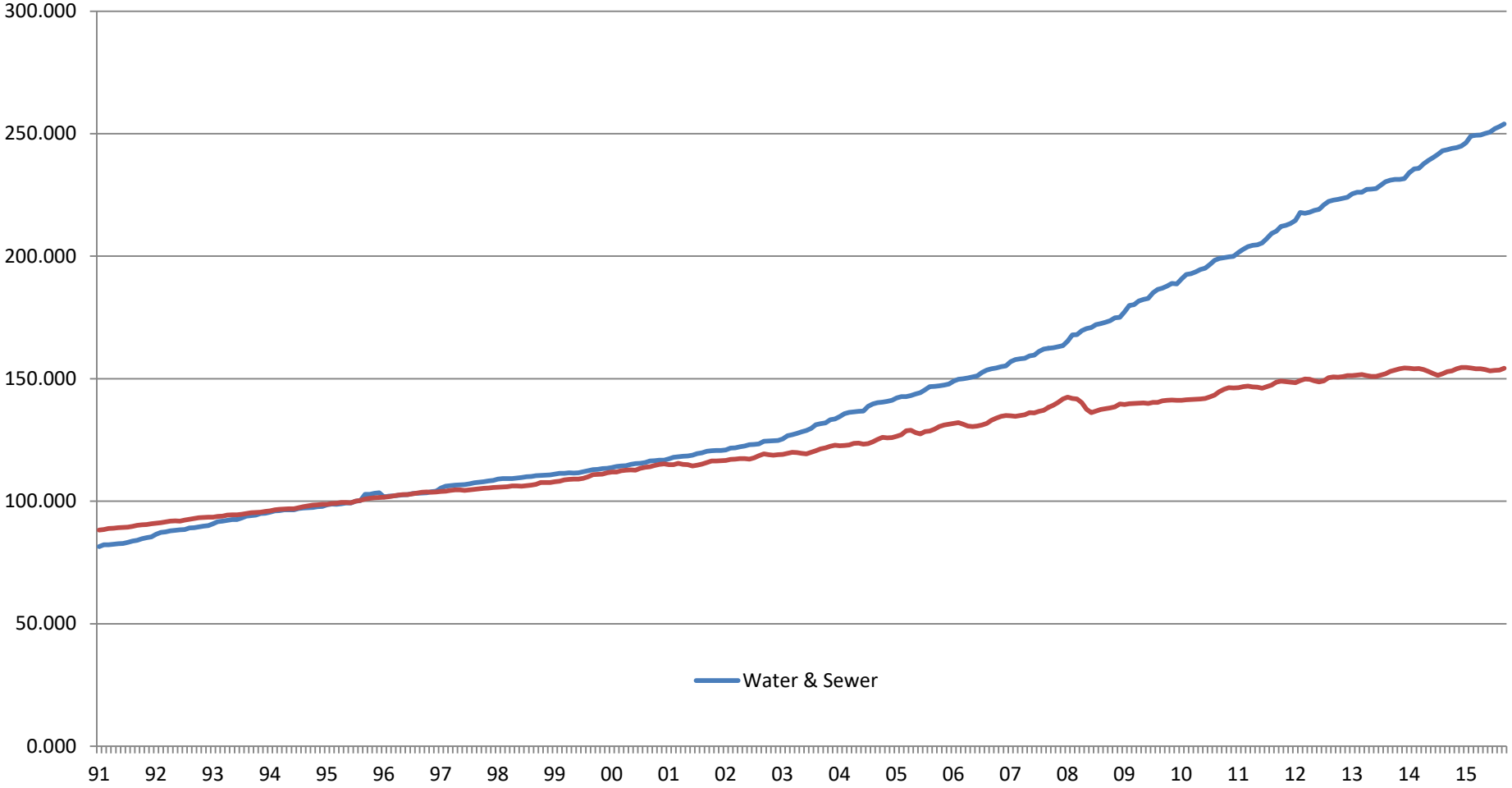
Costs are dominated by electricity, chemicals, and often, a pool service company.

Water is a much smaller expense.

Research on water rates suggests:

- The theory of consumer price perception does not hold for water utilities
- The costs of most “water uses” is mostly for items other than water
- The price of water and water demand are correlated, but the impact of price on demand is modest
- The impact of demand on price is much larger - cause and effect are largely reversed
- This may be reflected in inflation rates post-2000

Cost of water, sewer began deviating from all other goods and services post-2000



Conclusions – 1 of 2

Even if all conservation efforts were suspended, household demand would continue to decline for at least another decade. This is due to:

- "Passive conservation" driven by changes in tastes and preferences and more efficient devices
- Adding new, water-efficient houses to existing housing stock
- The long-term effects of previous conservation programs and standards

Conclusions – 2 of 2

Conservation efforts should focus on:

- Rigorous pilot programs to test promising new conservation technologies (e.g., bead washers)
- Rebate programs aimed at creating local markets for newer, proven technologies (e.g., dual flush toilets)
- Educational efforts to accelerate trends that increase water efficiency (e.g., pool removals)
- Innovative financing arrangements to assist budget-constrained households with significant conservation potential become more water efficient

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Decreasing demand forces rate increases

- Water utilities have large fixed costs, typically over 85%
- Energy and chemicals account for most of the variable costs
- When demand falls, revenues fall far more than costs
- This problem is exacerbated by IBRs
- The response is continually rising water (and sewer) rates
- This is reflected in inflation rates since 2000

Do customers react to MP or AP lagged?

Demand for water by well-informed, rational consumers:

$$Q = B_0 + B_1(I + D) + B_2 MP + B_3 Z$$

Demand for water by uninformed, rational consumers:

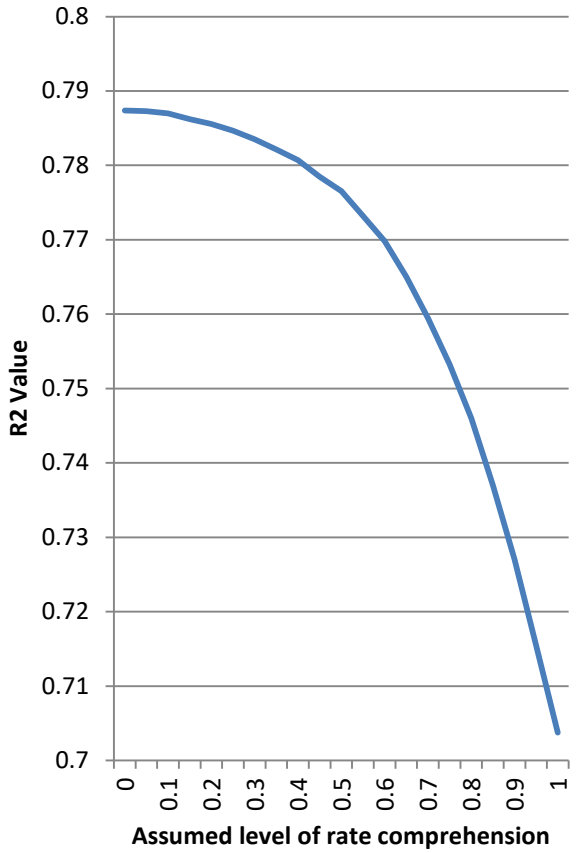
$$Q = B_0 + B_1 I + B_2 AP_L + B_3 Z$$

Demand for water by a mix of informed and uninformed consumers:

$$Q = B_0 + B_1(I + \alpha D) + B_2[AP_L + \alpha\,(MP - AP_L)] + B_3 Z$$

α varies from 0 to 1 and represents the fraction of consumers who are aware of the rate structure details and react to marginal price.

Analysis is consistent with uninformed customers

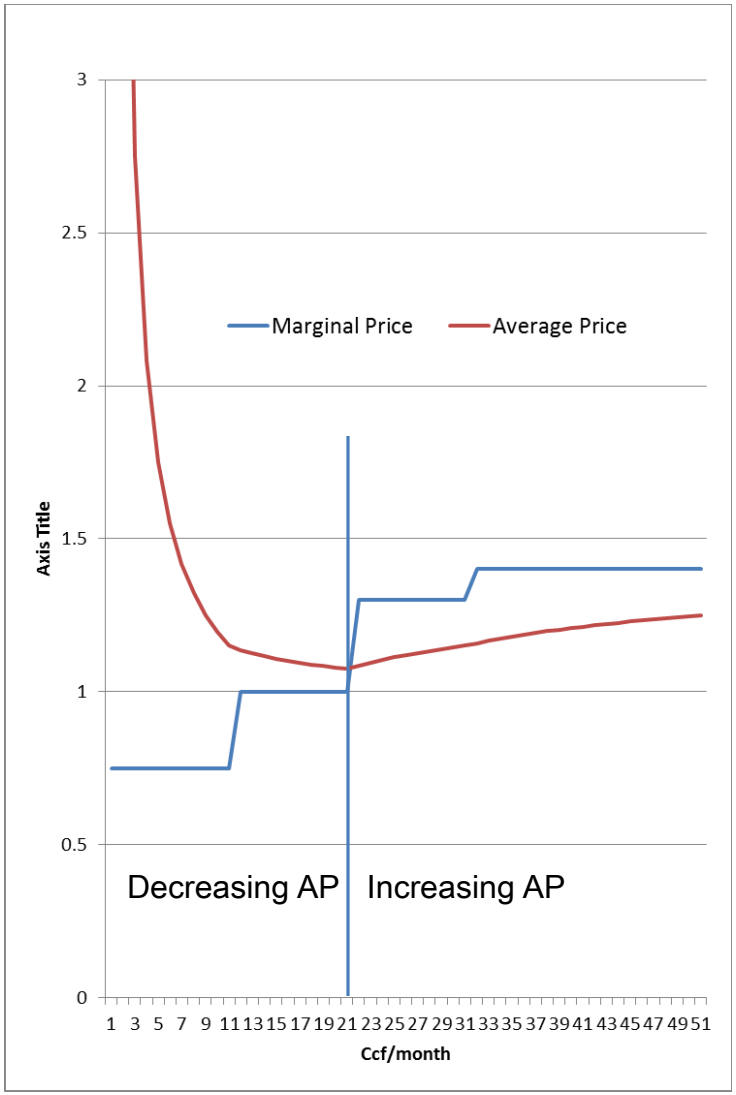


Separate research projects by Woodard and by Opaluch in the 1980s established that consumers who face complex, frequently changing rate structures react to lagged average price.

Research reported two years ago reached the same conclusion.

If most consumers are reacting to average price, then IBRs are ineffective.

What are the consequences of customers reacting to AP?



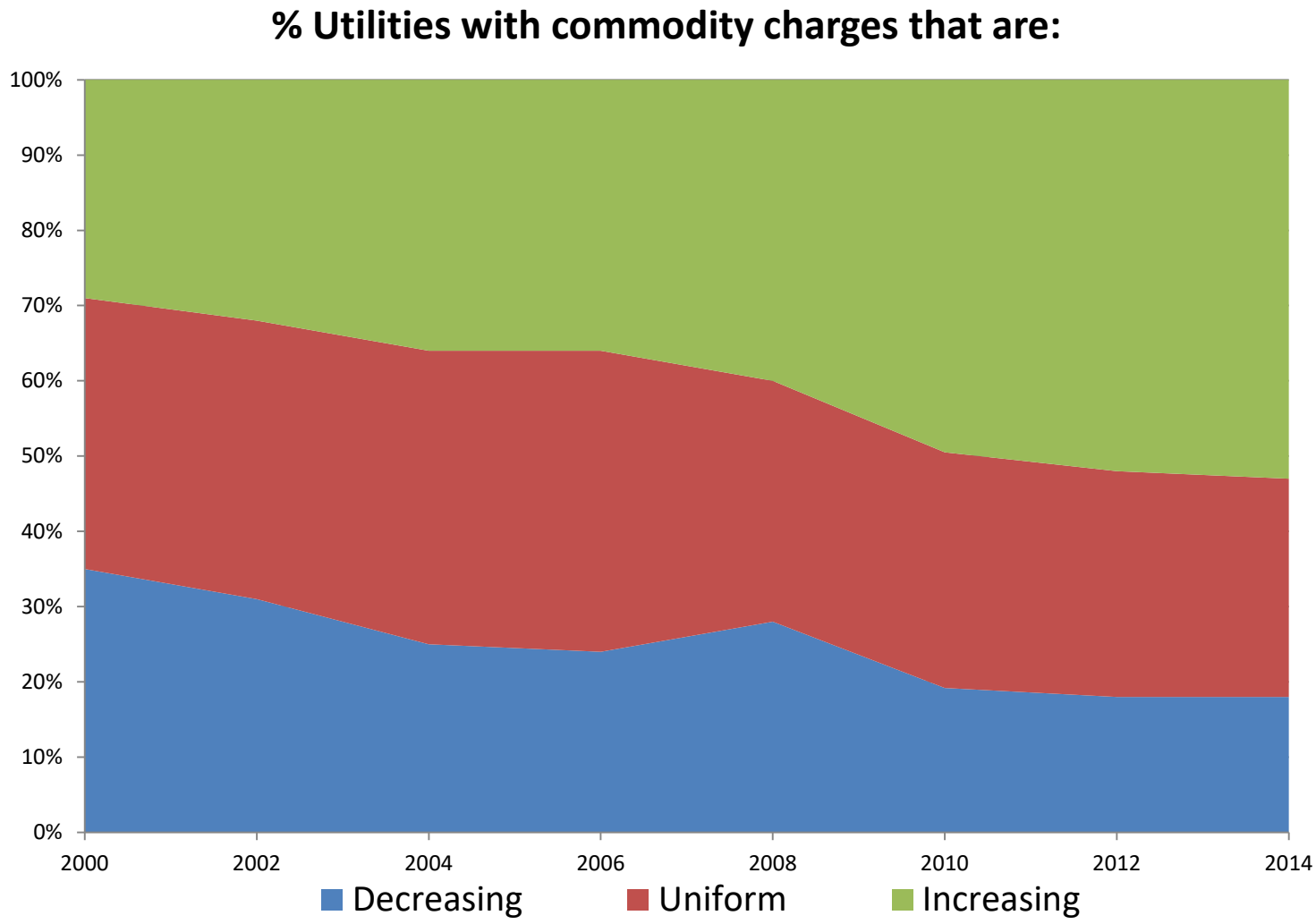
In the cases analyzed, most customers had water demand levels that resulted in them facing declining average price.

In other words, the more water they used, the lower their average price of water.

Pricing is a highly imperfect conservation tool

- The great majority of demand studies assume that consumers respond to marginal price
- The few demand studies that have compared marginal and average price have concluded consumers respond to lagged average price
- Rate schedules are complex, may adjust seasonally, and are frequently changed
- Water bills typically include sewer charges and other costs
- Water bills generally are among the smaller of household utility bills

Increasing block rates (IBRs) have become popular…



…but IBRs are particularly problematic

- Consumers do not respond to marginal price, so the underlying theory of IBRs is deeply flawed
- The few demand studies that have compared marginal and average price have concluded consumers respond to lagged average price
- Rate schedules are complex, may adjust seasonally, and are frequently changed
- Water bills typically include sewer charges and other costs
- Water bills generally are among the smaller of household utility bills

Consumers are unaware of marginal price!