IPART Workshop

Estimating water demand for Sydney Water Corporation

11 November 2011

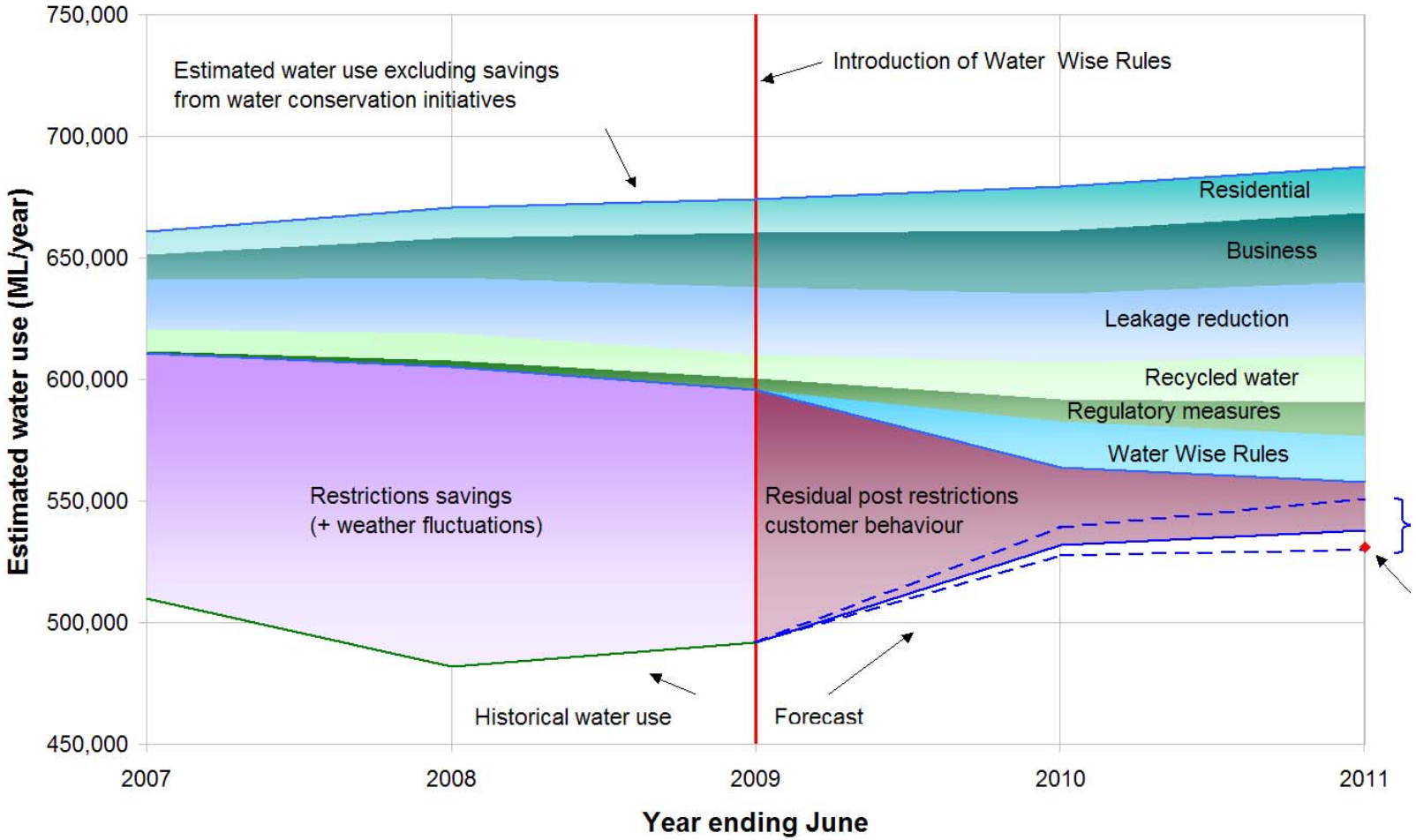
Agenda topics

- Why was a new water demand model developed?
- What are the key features of the model?
- Outline the major assumptions behind the model
- Outcomes of the model for future water demand
- Explain how water demand model been peer reviewed

Why develop new models?

Previous framework

426 LPD less water conservation and drought restrictions



Why develop new models?

1. **2008 Review by McLennan Magasanik Associates (MMA):**

- MMA raised a number of concerns over the 426 LPD framework, that limited its 'usefulness'
  - masks a large number of underlying trends
- Preferable to directly forecast residential and non-residential water use

2. **Eight years of over forecasting water use**

3. **New models were needed to better understand:**
   - Structural shifts in water use patterns
   - Long-term water use given end of drought and Water Wise Rules

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Key features of the new models

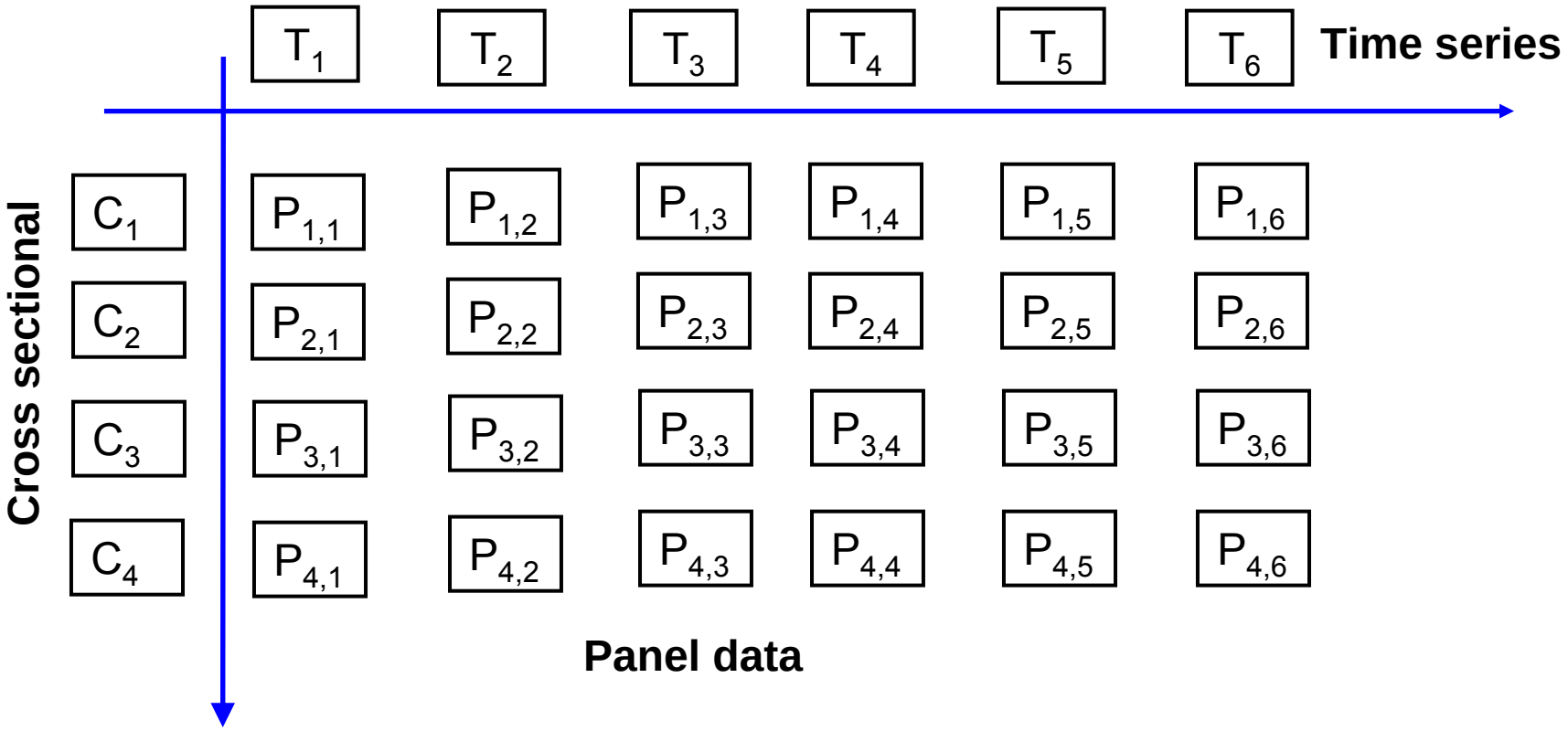
New approach - summary

The new models directly forecast residential, non-residential and 'non-revenue' water

- Residential: Panel data econometric models
- Non-residential: Time series econometric models
- Non-revenue: Leakage target & industry standards (e.g customer meter under reads)

Residential models

Panel data analysis



Residential models

Key advantage: Panel data greatly increases the available information

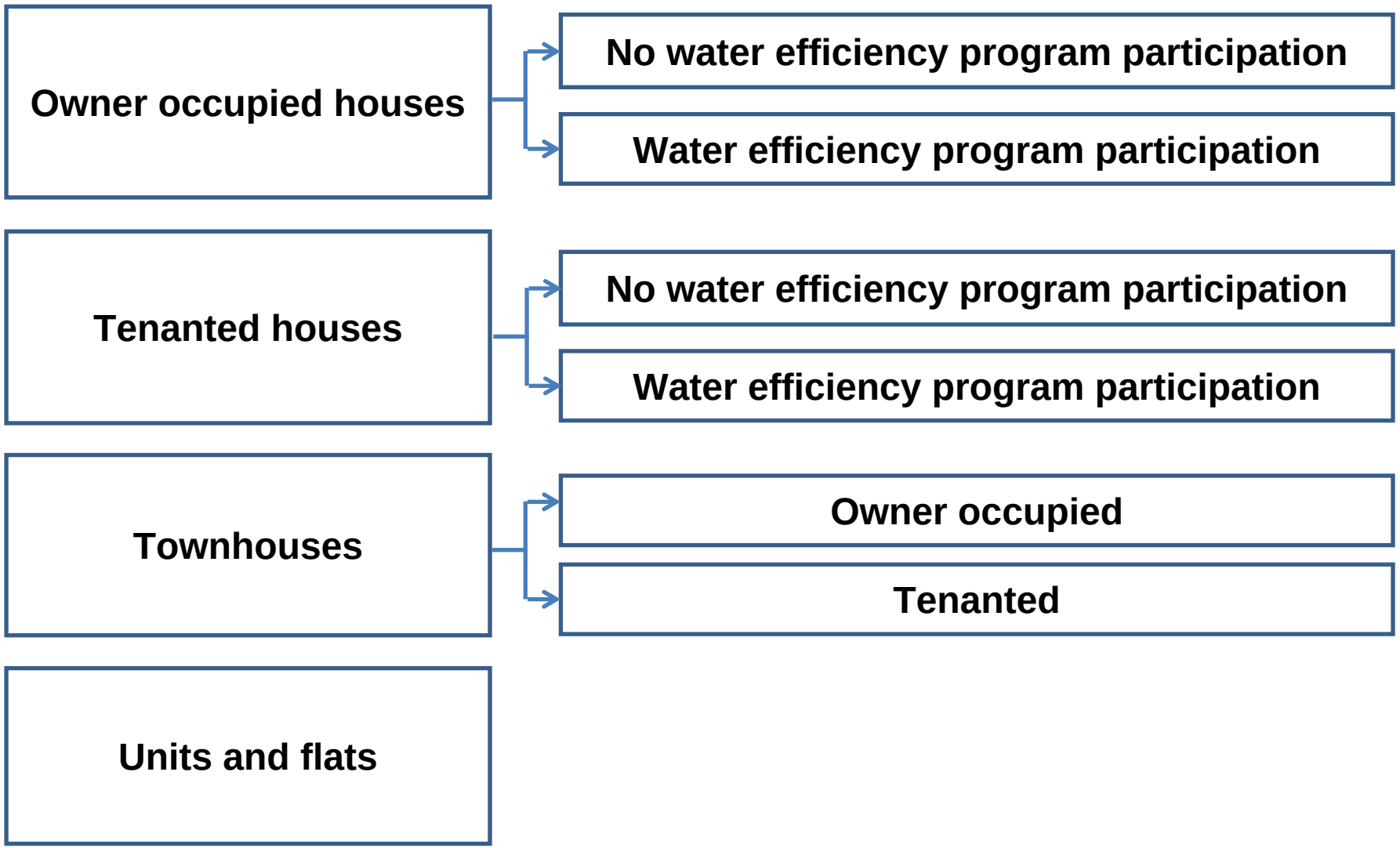
- More accurate inferences over how factors influence water use
- Provide the micro foundations for aggregate analysis
  - Aggregate models of water use (eg total residential or bulk water) suffer 'aggregation bias' problems
- Control for unobserved factors

Residential models

Stratified random sample:

- Over 132,000 households
  - About 10% of total residential households
  - Over 90% of households by type represented
- July 2004 to December 2010 (27 readings)
  - 18 months of Water Wise Rules
  - About 3.6 million observations
- Explanatory variables created to match the meter reading periods of individual households

User groups


Owner occupied houses
No water efficiency program participation
Water efficiency program participation
Tenanted houses
No water efficiency program participation
Water efficiency program participation
Townhouses
Owner occupied
Tenanted
Units and flats

Clustering analysis

Clustering analysis of houses undertaken based on property size

- Find ‘natural’ groupings of households
- Allows each cluster its own response to changes in the explanatory variables
- Partitional approach to developing clusters

Clustering analysis

User group	No. of households	No. of clusters
Owner occupied houses		
No water efficiency participation	46,631	17
Water efficiency participation	41,496	31
Tenanted houses		
No water efficiency particiption	10,334	7
Water efficiency participation	5,296	7
Townhouses		
Owner occupied	10,267	1
Tenanted	11,327	1
Units and flats (blocks)	**6,832**	1
Total	**132,183**	**65**

Dynamic model specification

Assumes that households, on average, react over time to changes in explanatory variables:

- Short- and long-run impacts to changes in explanatory variables
- Time to adjust to long-run positions

Changes in variables vs levels of variables

- Some variables that explain differences across households not necessarily important for forecasting (eg pool ownership)
- Differences to levels through estimated constant term

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Dynamic model specification

Auto regressive distributed lag model (ARDL)

$$\ln c_{it} = \alpha \cdot \ln c_{it-1} + \sum_{j=0}^{5} \beta_j \cdot price_{it-j} + \gamma \cdot raindev_{it} + \gamma_1 \cdot evapdev_{it} +$$

$$\sum_{j=0}^{1} \lambda_j \cdot waterfix_{it-j} + \sum_{j=0}^{1} \phi_j \cdot wmr_{it-j} + \sum_{j=0}^{1} \theta_j \cdot diy_{it-j}$$

$$+ \gamma_2 \cdot L2R_{it} + \sum_{j=1}^{4} \delta_j \cdot season_{itj} + \sum_{j=1}^{4} \rho_j \cdot WWRseason_{itj} + u_{it},$$

$$u_{it} = \eta_i + \varepsilon_{it}, \quad |\alpha| < 1,$$

- First differences
- Temperature deviation and a vacancy rate for units & flats
- Income and disposable income not significant
- ‘Interactive’ variables not significant

Estimation technique

Large cross section with 27 meter reading sequences

Endogenous regressors - price and previous consumption

- Ordinary least squares – biased and inconsistent estimators
- Maximum likelihood – sensitive to initial specification
- Preferred approach: ‘Two step’ generalised method of moments (GMM)

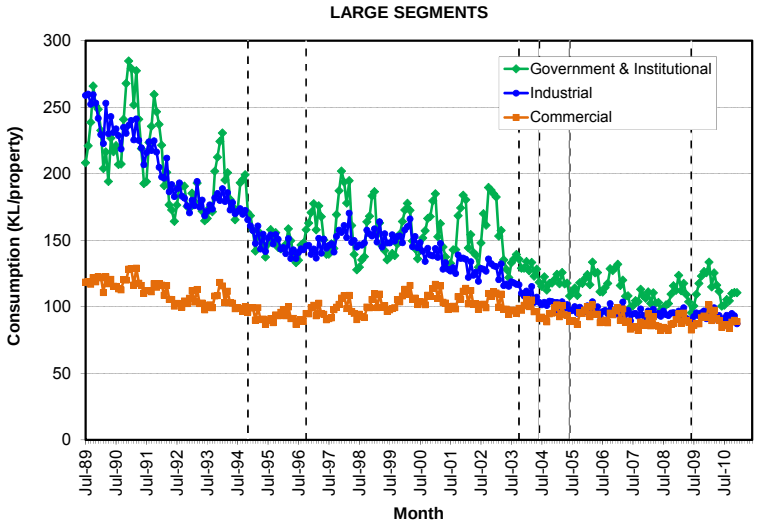
Residential

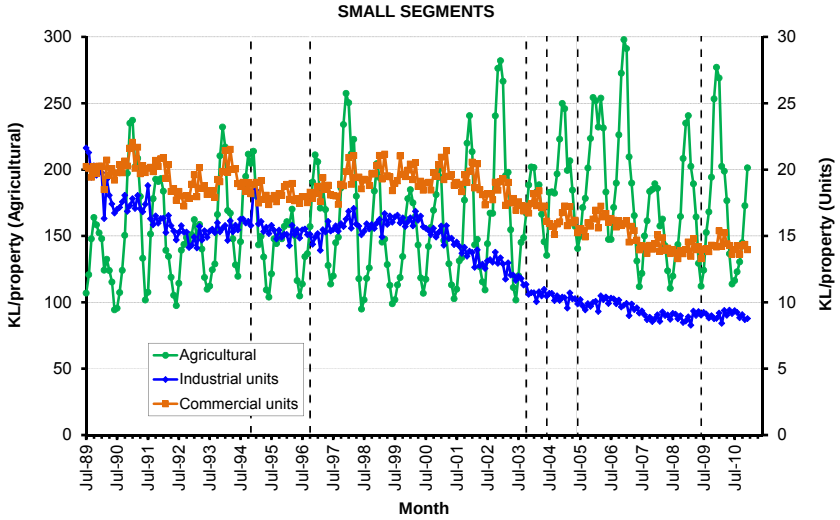
Aggregate residential water use forecasts are built up from the 65 econometric models

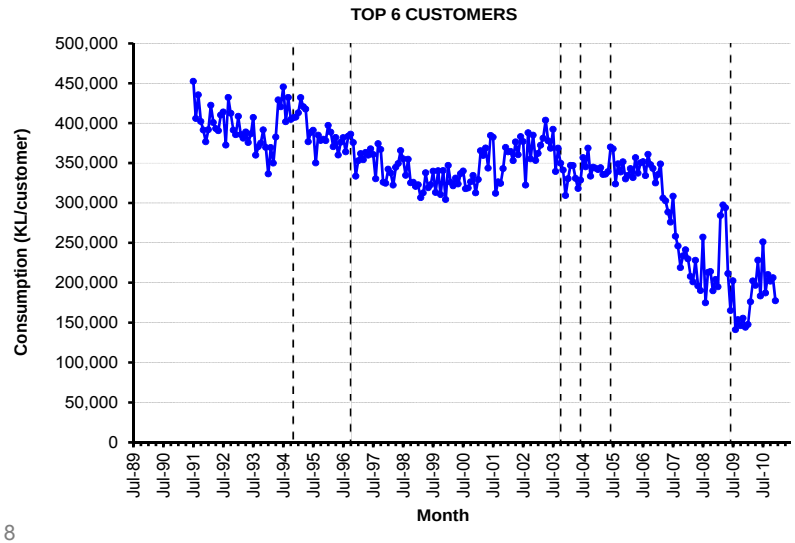
1. Weighted average model for each user group
   - Number of households in each cluster
2. Water use (by user group) = average water use per property * number of properties

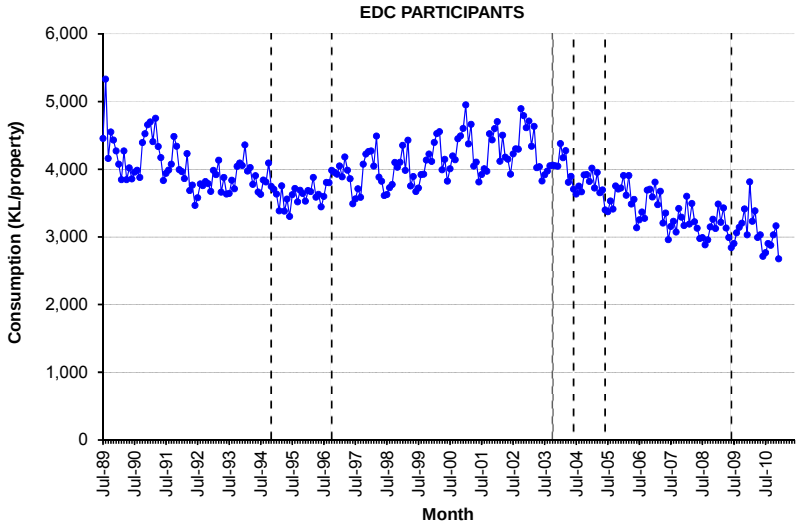
Non-residential

Segmentation by property type, participation in water efficiency programs and level of water use (Top 6)









Non-residential

Time trend model for each segment including seasonal, weather and Water Wise Rules variables.

$$\bar{q}_{(m,y)} = \bar{q}^{*}_{(m,y)} \times s_m$$

$$\bar{q}^{*}_{(m,y)} = \alpha + \beta_1 \times \Delta\bar{T}_{(m,y)} + \beta_2 \times \Delta\bar{E}_{(m,y)} + \beta_3 \times \Delta\bar{R}_{(m,y)} + \beta_4 \times t_{(m,y)} + \beta_5 \times WWR_{(m,y)} + \varepsilon_{(m,y)}$$

$\bar{q}^{*}_{(m,y)}$ = deseasonalised average daily demand

s_m = monthly seasonal factor

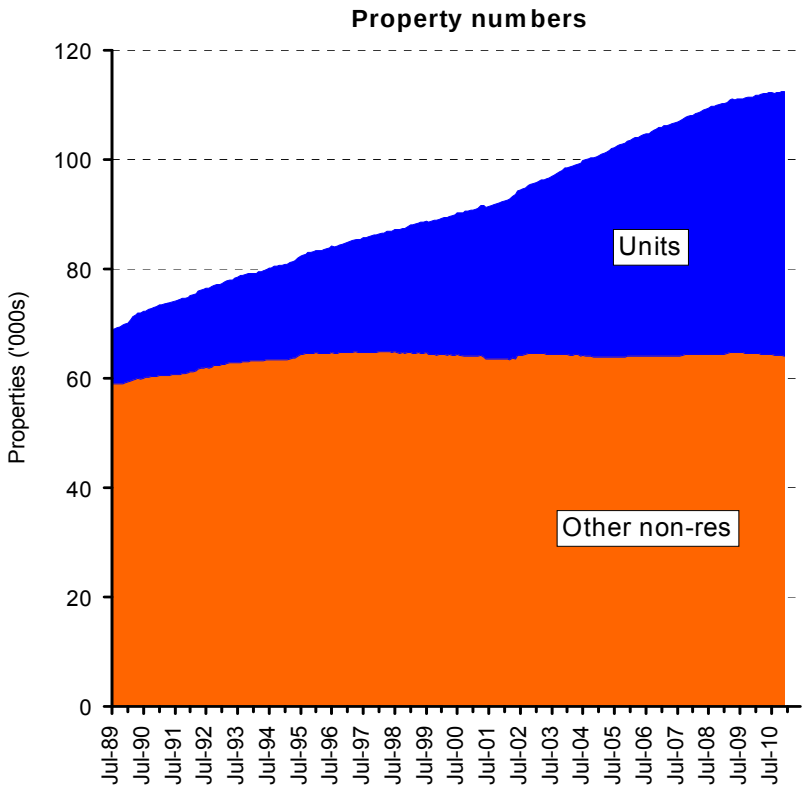
$\Delta\bar{T}_{(m,y)}, \Delta\bar{E}_{(m,y)}, \Delta\bar{R}_{(m,y)}$ = deviation of maximum temperature, evaporation and rainfall from their seasonal average

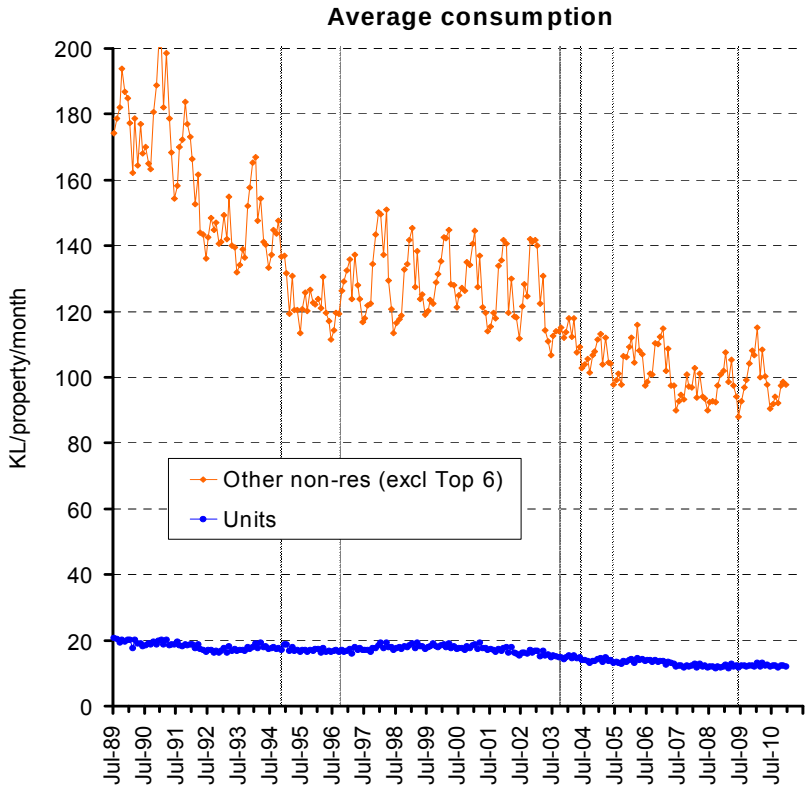
$t_{(m,y)}$ = time measured in months ($t_{10,2003} = 1$)

$WWR_{(m,y)}$ = dummy variable indicating Water Wise Rules

Non-residential

- Virtually all growth is in non-residential units
- These property types use very little water





Non-residential

Forecasting approach

For each segment:

1. Forecast average water use per property
   - Extrapolate trend
   - Long-term average weather conditions
2. Multiply by the number of properties
3. Adjust for planned recycling projects

Major findings and assumptions

Residential models

Major finding

- Households have fully adjusted to Water Wise Rules
  - findings from the econometric models
  - survey and other evidence

Major assumptions

- Water usage prices
  - currently increases to Sydney Water's estimate of the long run marginal cost of water
- Long-term average weather conditions

Non-residential

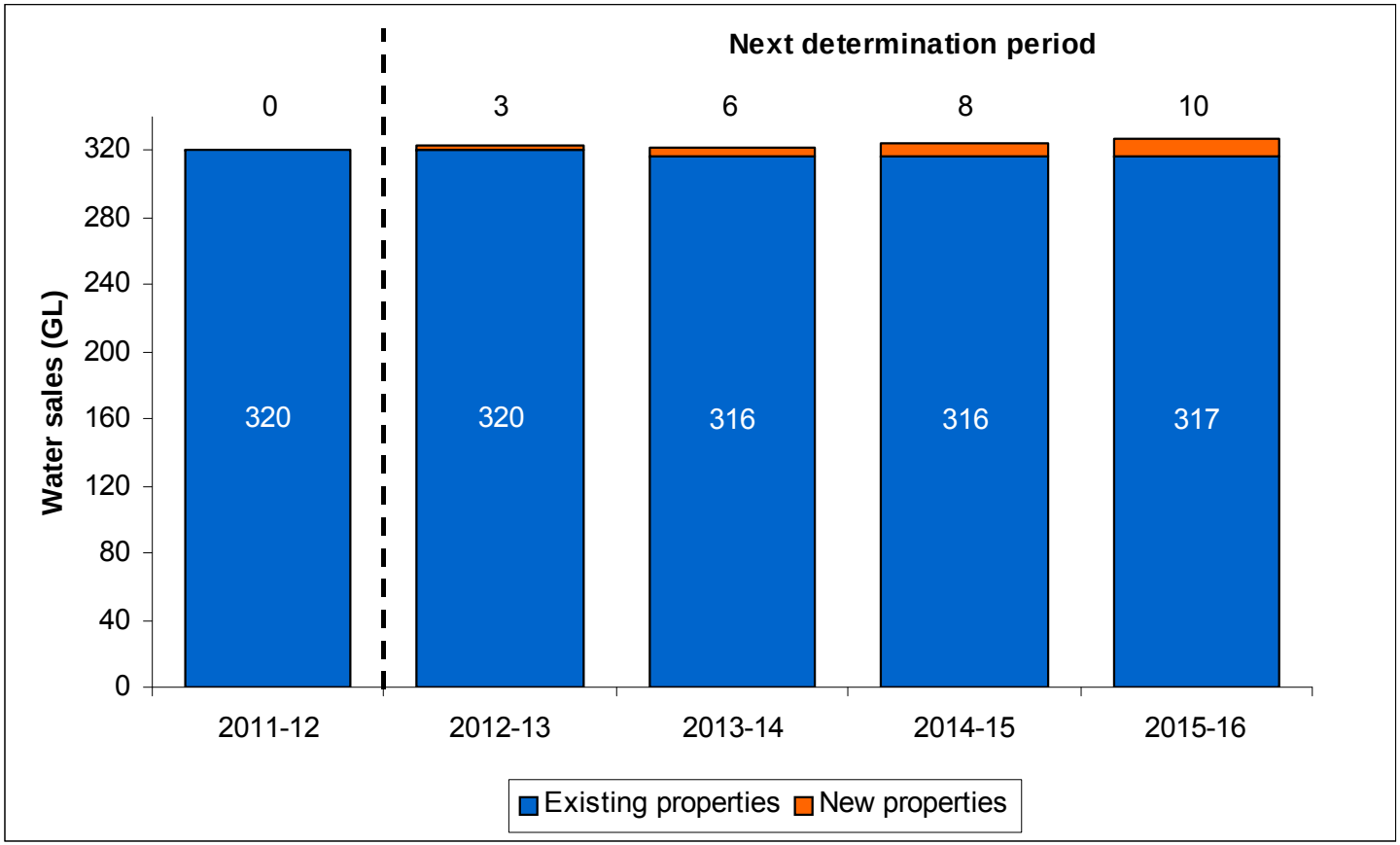
- Estimated downward trends in average water use will continue:
  - EDC participants: No further trend post July 2011
  - Agricultural and non-res units: constant average demand at levels since Water Wise Rules
- Full adjustment to Water Wise Rules
- Long-term average weather conditions

Non-residential

- Property growth dominated by non-residential units
- Partial shutdown Port Kembla steelworks
- Additional recycling
  - Camellia recycled water project: about 4 GL/year from October 2011
  - Kurnell sewer mining project: about 1.4 GL/year from August 2012

Model outcomes

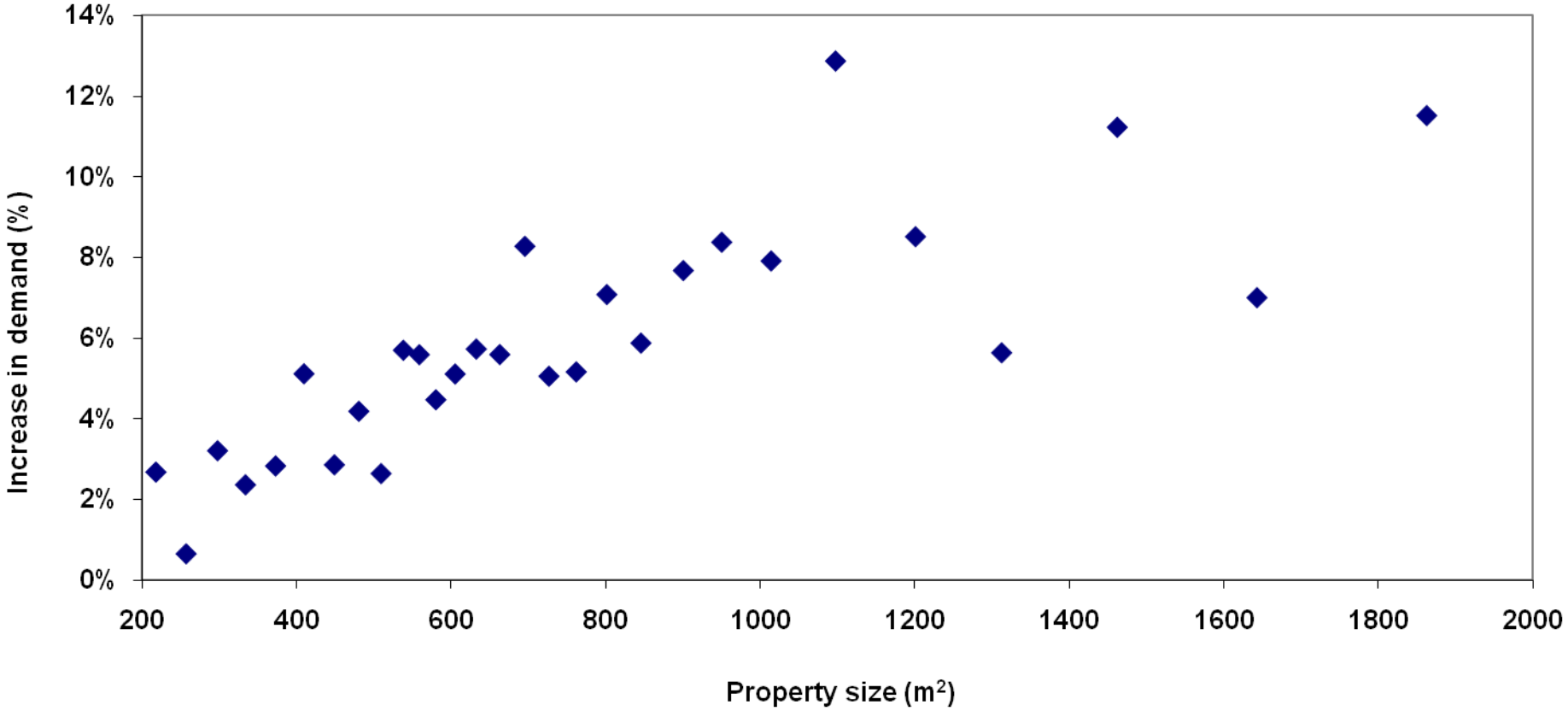
Residential water use



Includes unmetered billed water use

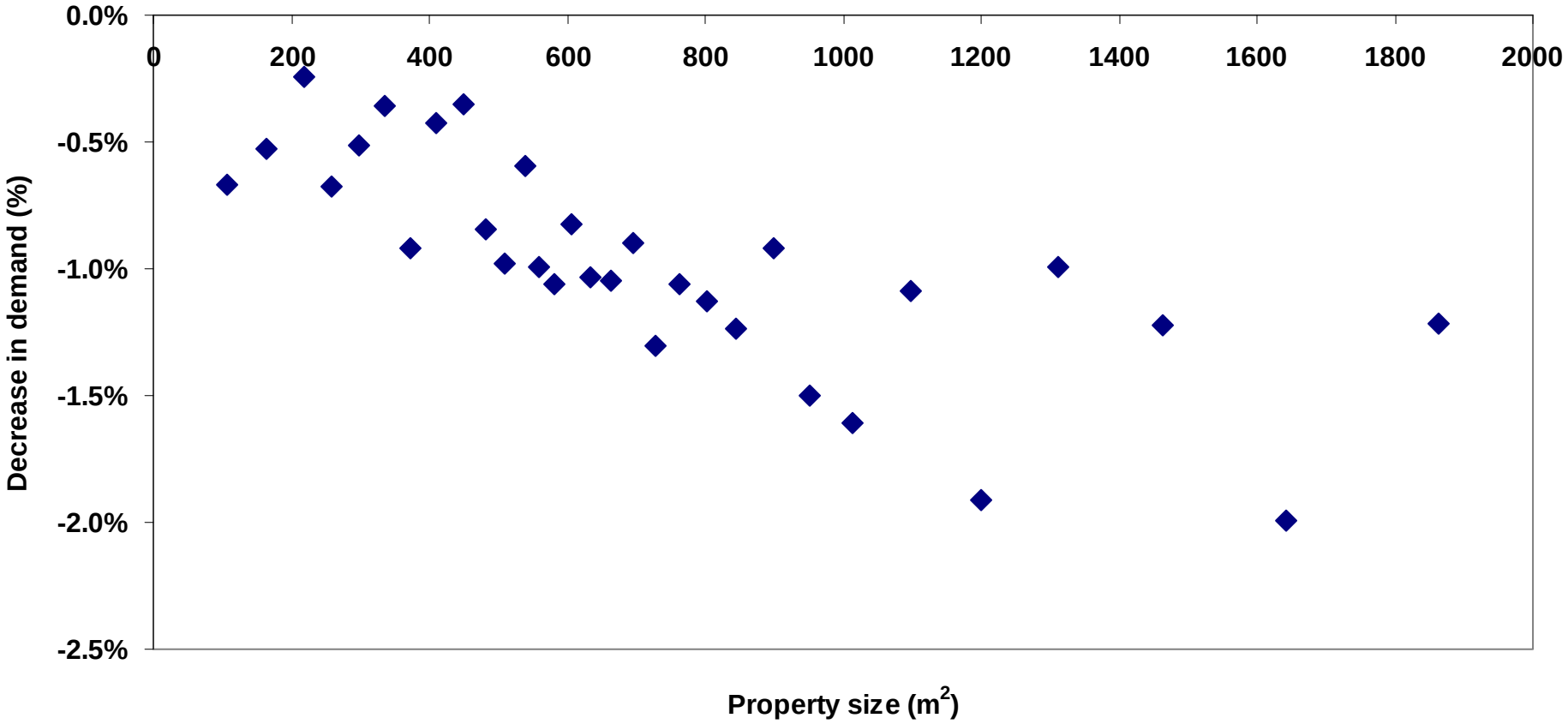
Owner occupied houses, WE

Impact of a 1mm increase in average evaporation levels



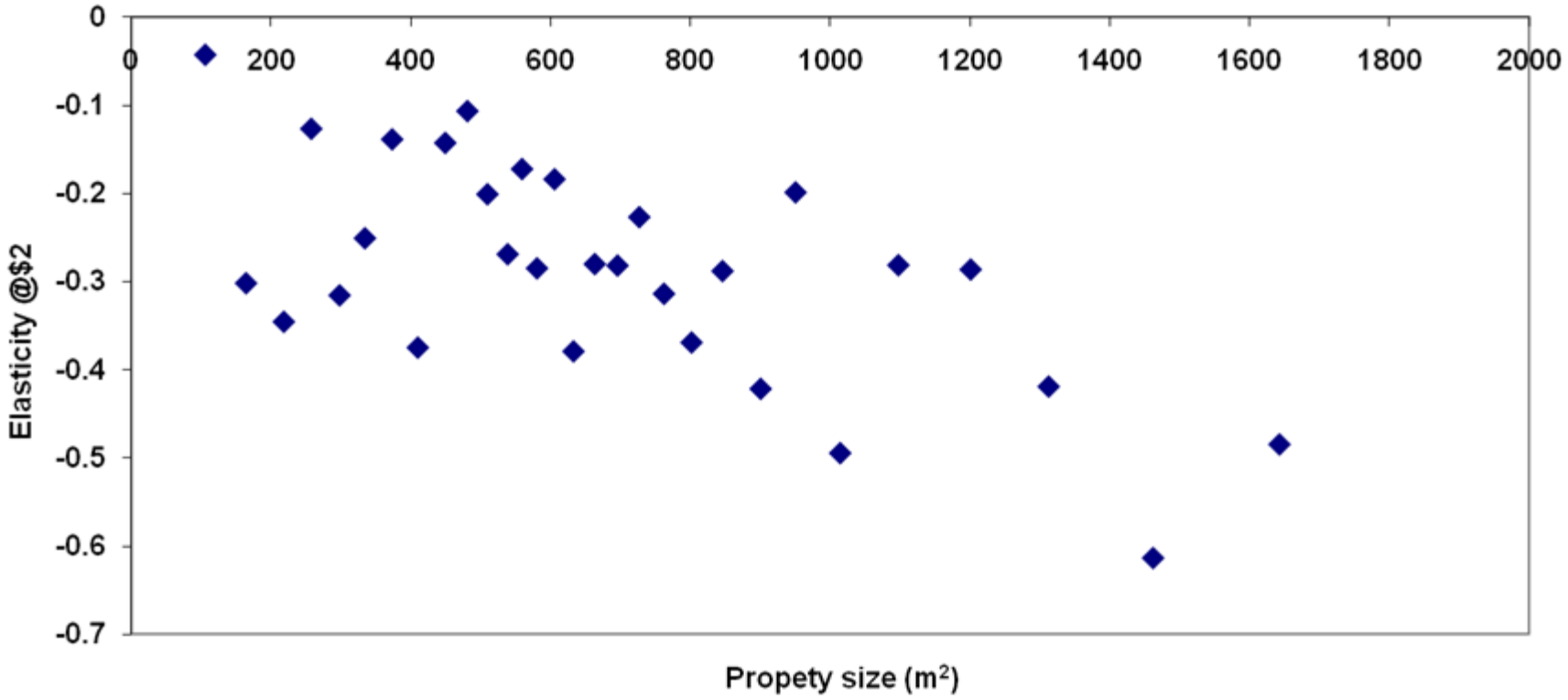
Owner occupied houses, WE

Impact of a 1mm increase in average rainfall levels



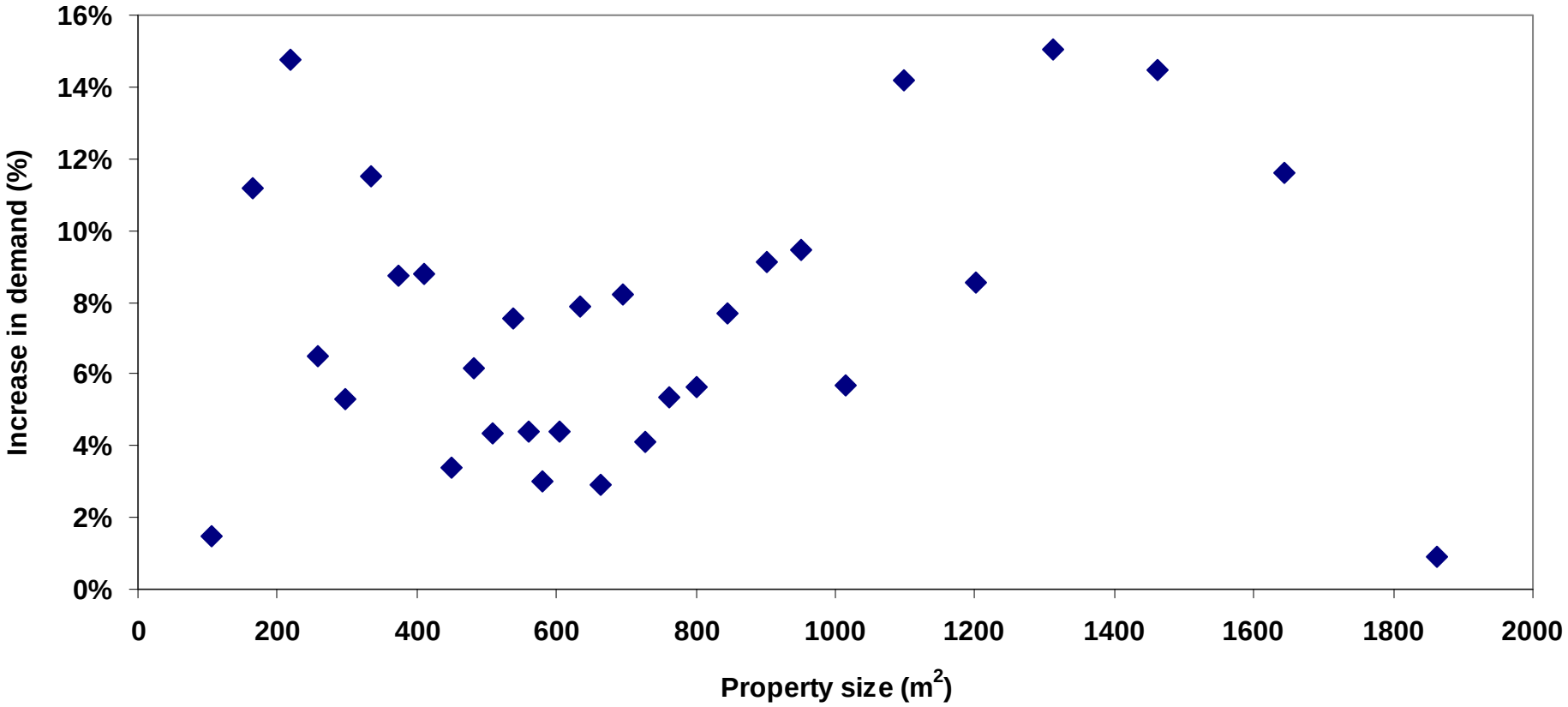
Owner occupied houses, WE

Long-run price elasticity @ $2.00 per kL



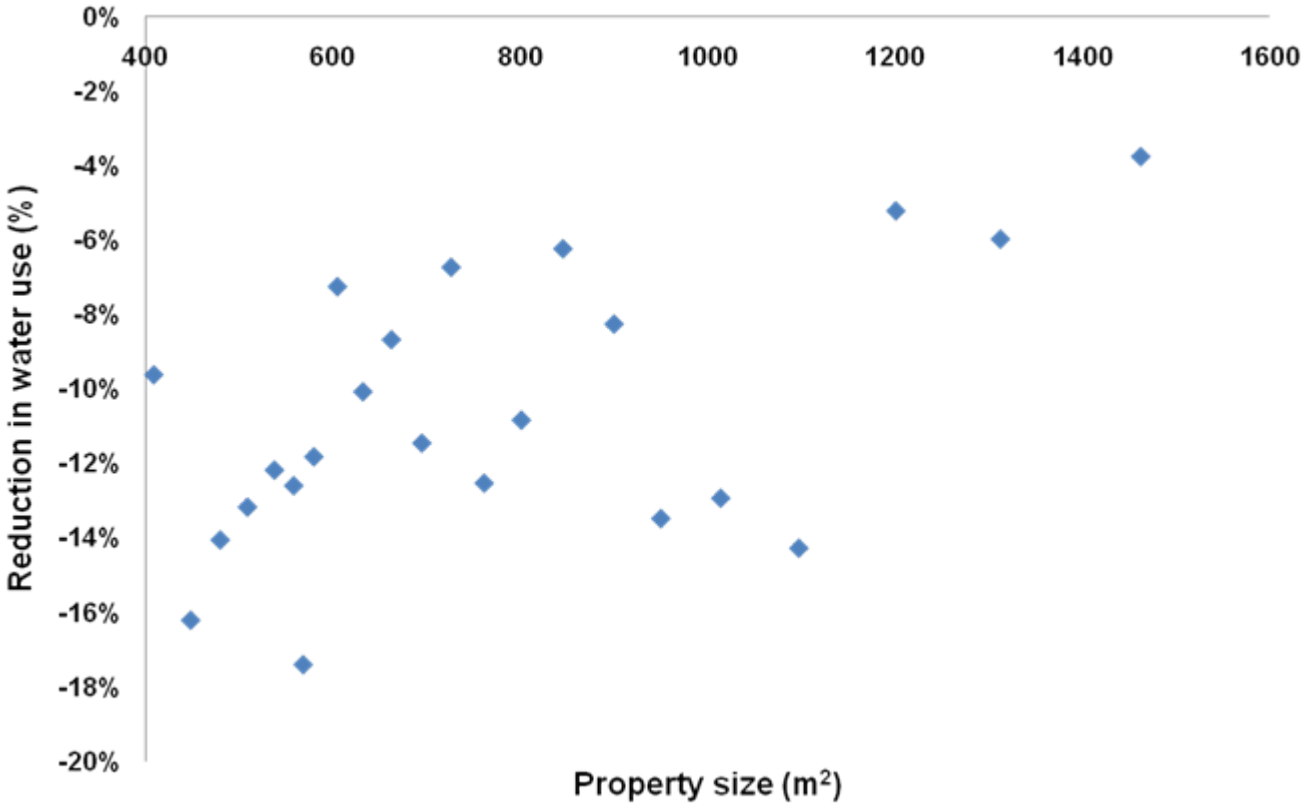
Spring and WWRs

Long run impact of WWRs on spring water use levels



Water efficiency

Estimated impact of WaterFix



Average impact: about 23kL/year reduction in water use

Finding: Water Wise Rules

Increase in water use with replacing drought restrictions with Water Wise Rules (22 June 2009)

	% increase		kL/year	
Property type	**SR**	**LR**	**SR**	**LR**
Owner occupied houses, no water efficiency program	3.8%	6.0%	8	13
Owner occupied houses, water efficiency program	2.5%	3.3%	5	6
Tenanted houses, no water efficiency program	1.9%	3.4%	4	7
Tenanted houses, water efficiency program	2.1%	3.8%	4	8
Units and flats	2.1%	4.4%	3	6
Owner occupied townhouses	3.3%	5.0%	4	7
Tenanted townhouses	1.2%	2.2%	2	4

13 GL long-run increase in water use (4.3%)

Finding: Water Wise Rules

Time taken to adjust >98% to the long-run position

Property type	α	Months	Date*
Owner occupied houses, no water efficiency program	0.35	12	June 2011
Owner occupied houses, water efficiency program	0.23	9	March 2011
Tenanted houses, no water efficiency program	0.42	15	Sept 2011
Tenanted houses, water efficiency program	0.43	15	Sept 2011
Units and flats	0.51	18	Dec 2011
Owner occupied townhouses	0.32	12	June 2011
Tenanted townhouses	0.44	15	Sept 2011

***Measured from July 2010 given seasonal WWRs variables**

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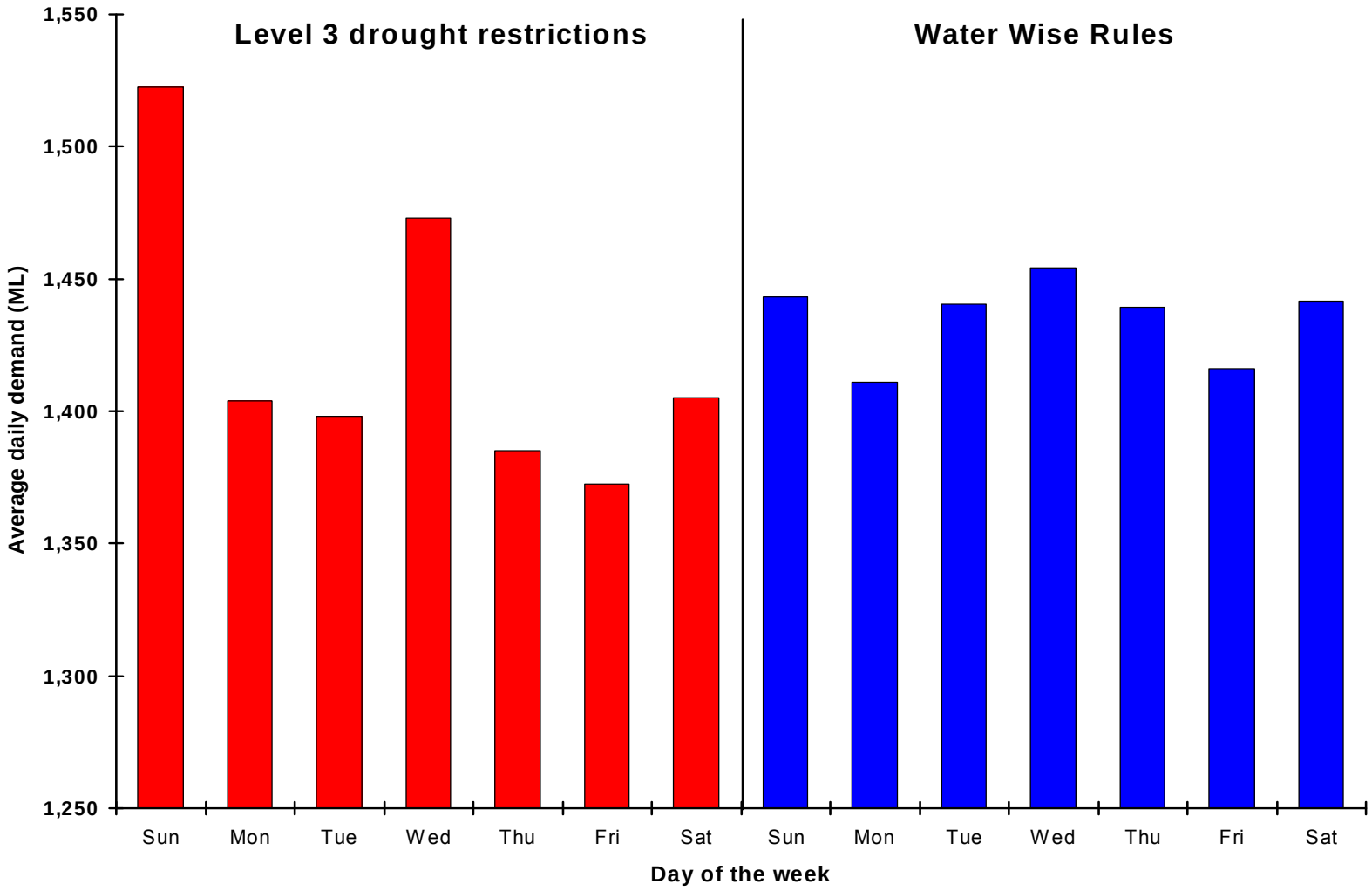
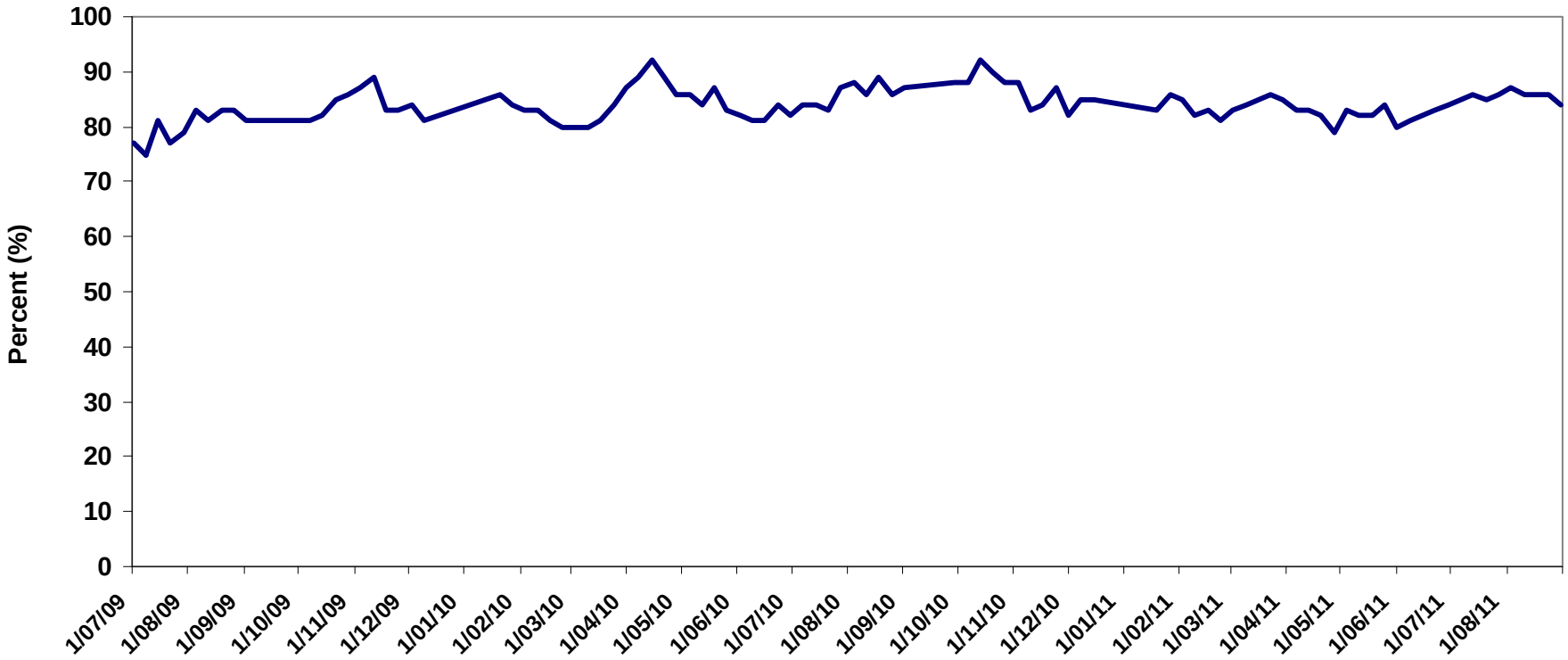
Finding: Water Wise Rules

Weekly water use patterns



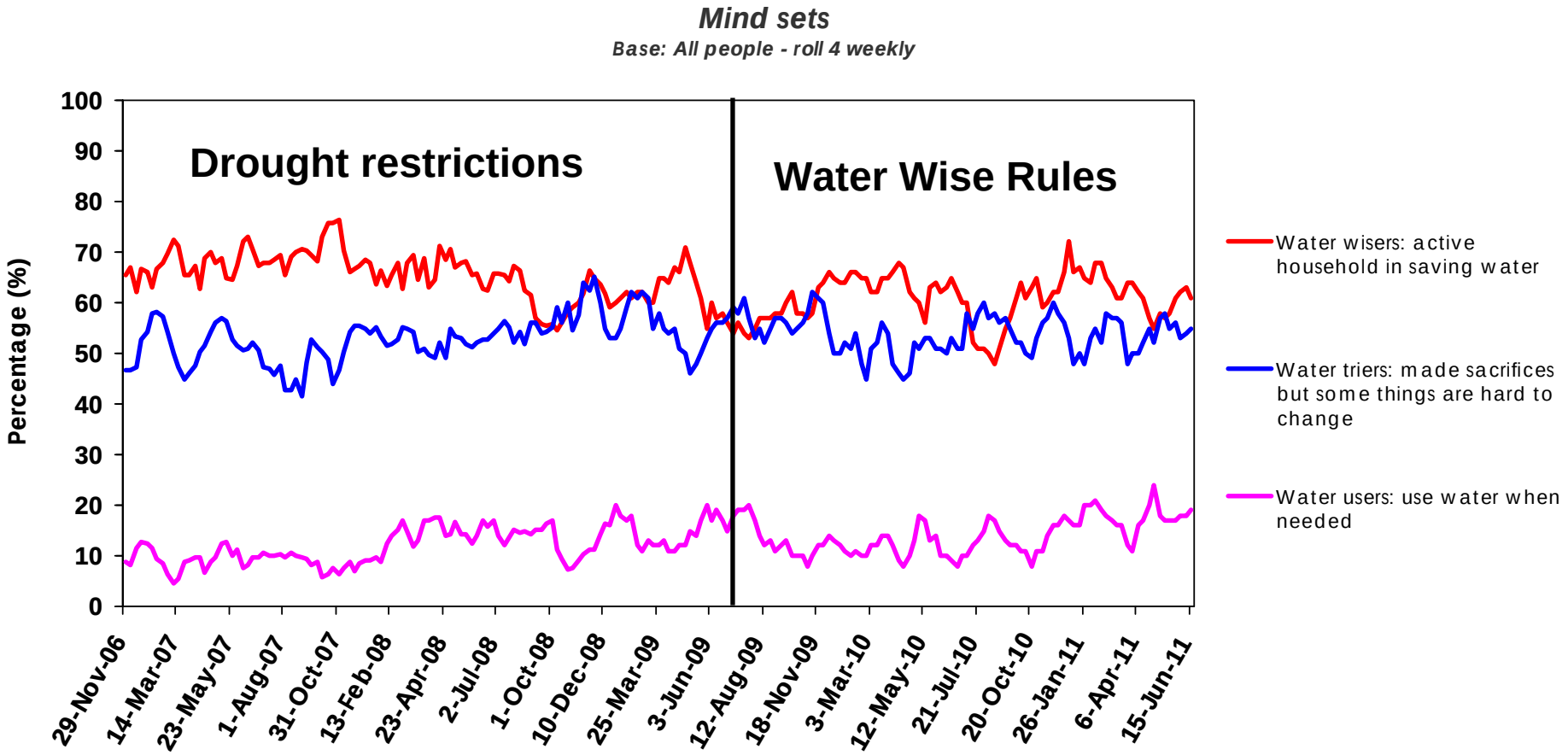
Finding: Water Wise Rules

Continued high support for Water Wise Rules



Finding: Water Wise Rules

Attitudes to water use



Assumption: Water usage prices

Assume households become more sensitive to price the higher the level of prices

	LR price elasticity	
Property type	**1.50 kL**	**2.00 kL**
Owner occupied houses, no WE	-0.29	-0.38
Owner occupied houses, WE	-0.20	-0.26
Tenanted houses, no WE	-0.16	-0.22
Tenanted houses, WE	-0.14	-0.19
Units and flats	-0.09	-0.12
Owner occupied townhouses	-0.27	-0.36
Tenanted townhouses	-0.10	-0.13

Real water usage price increases

Pre Water Wise Rules(June 2009) to present:

- $1.65kL to $2.00kL ($June 2009):
- About 12 GL reduction by 30 June 2012
- Almost fully offsets the move to Water Wise Rules

Proposed gradual move to LRMC:

- $2.20kL (1 July 12) to $2.35kL (1 July 15) ($11-12)
- About 3 GL reduction (existing properties) by 30 June 2016
- Can run alternative price scenarios

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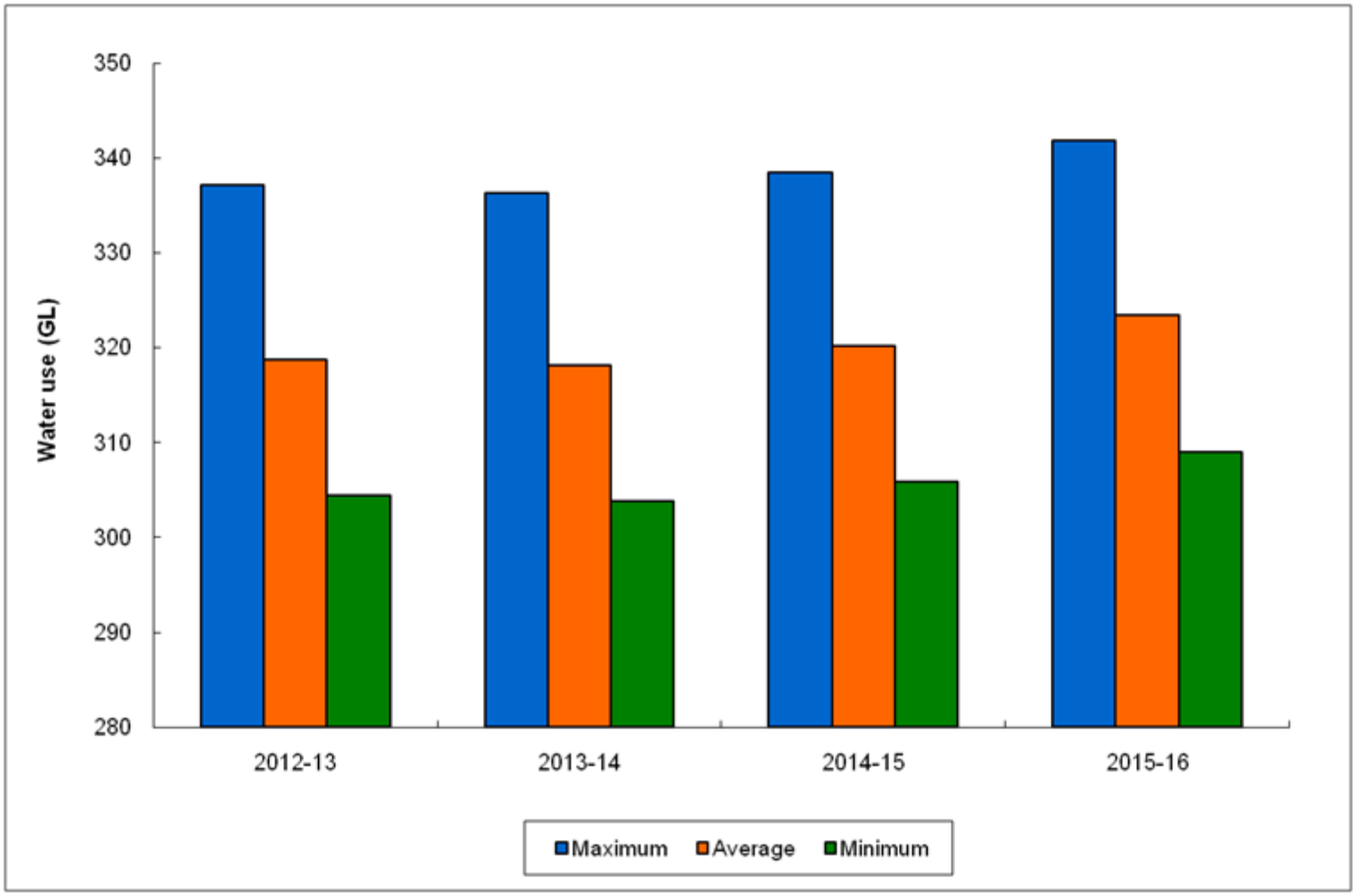
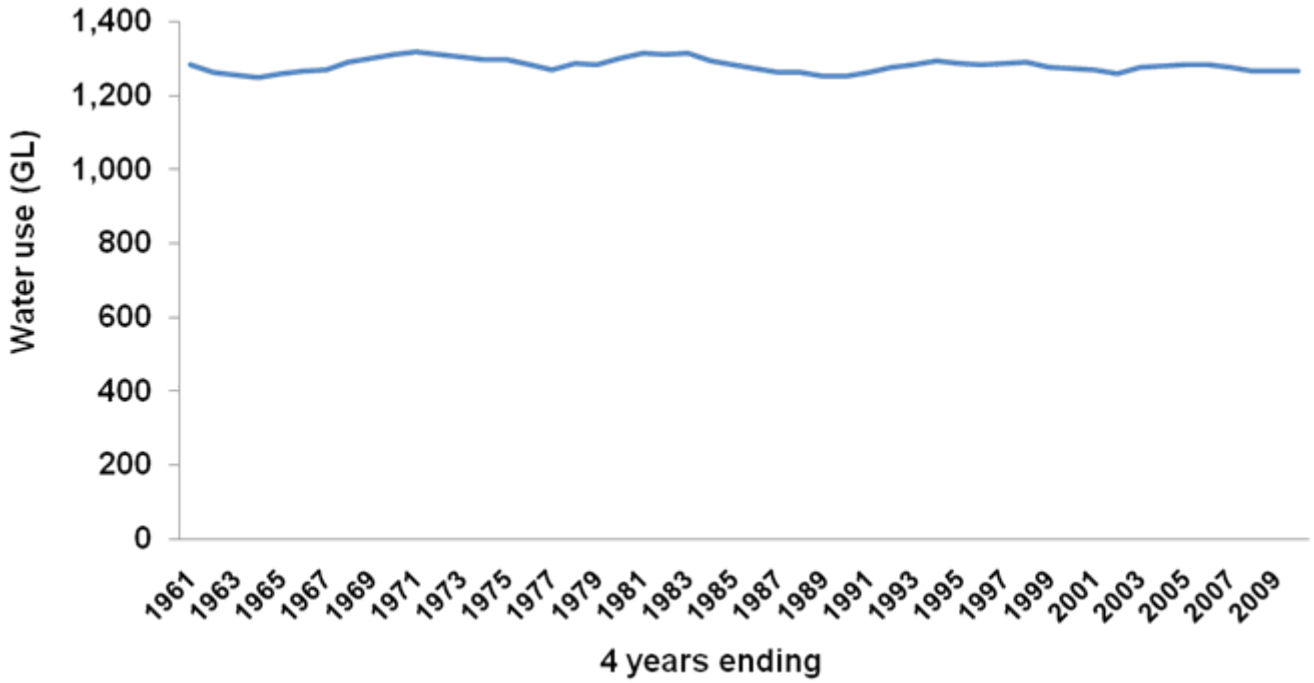
The weather – individual years

+ 18GL (+6%) to -14 GL (-5%) (2012-13)



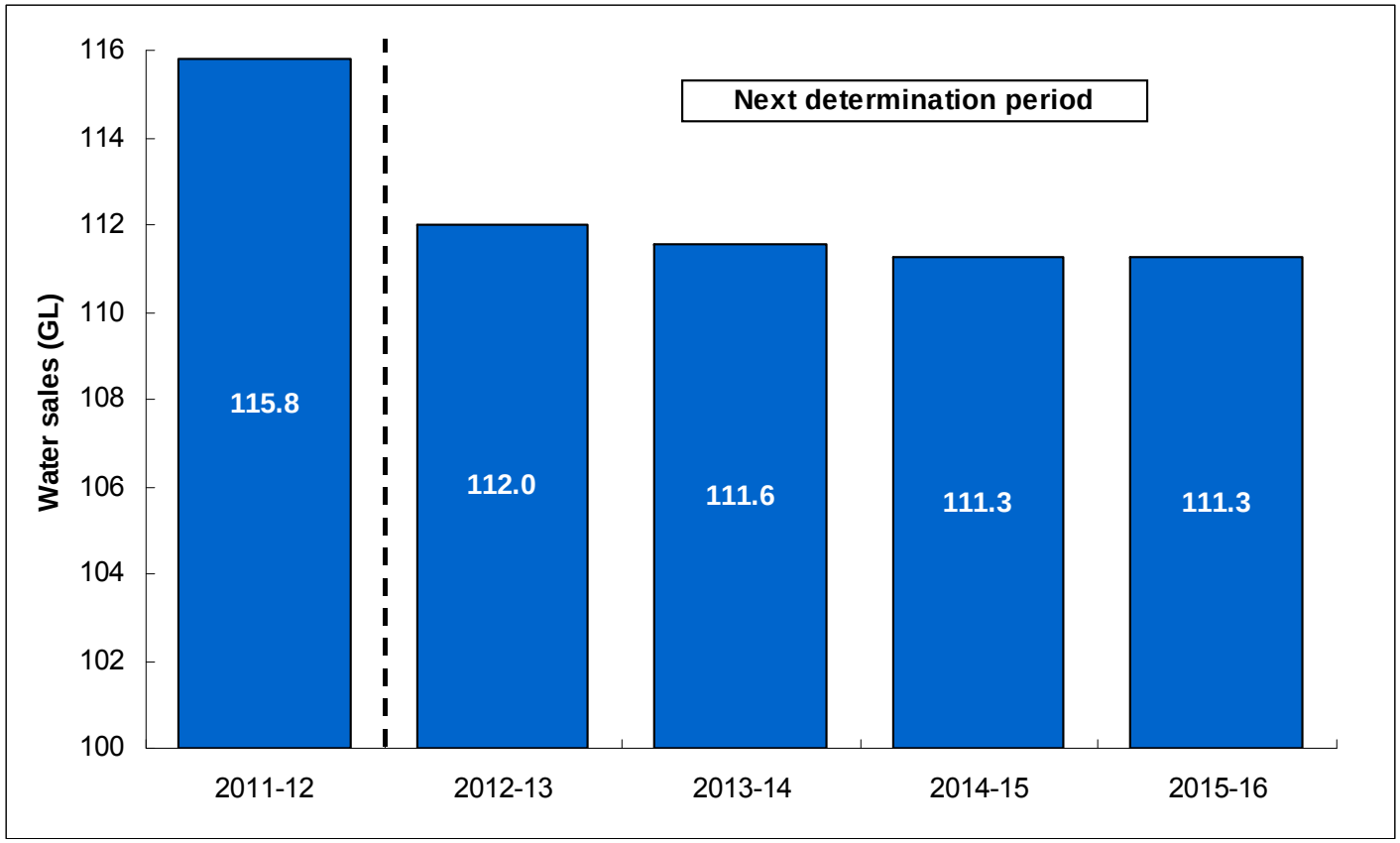
The weather – 4 years

4 year moving average from 1960-61 to 2009-10 (residential)



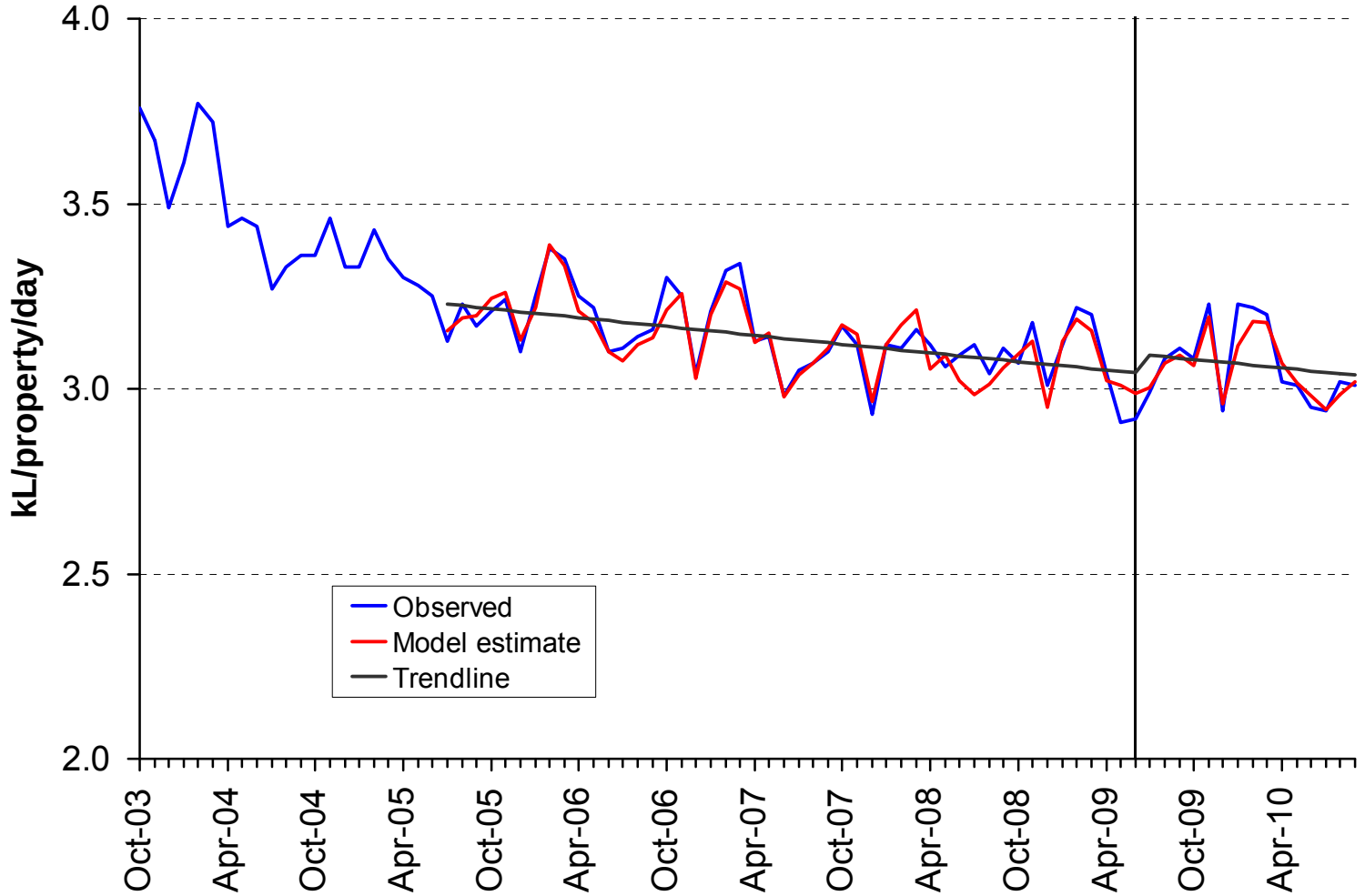
Average: **1,282 GL**
Maximum: **1,319 GL (+37 GL, +2.8%)**
Minimum: **1,251 GL (-31 GL, -2.5%)**

Non-residential - summary

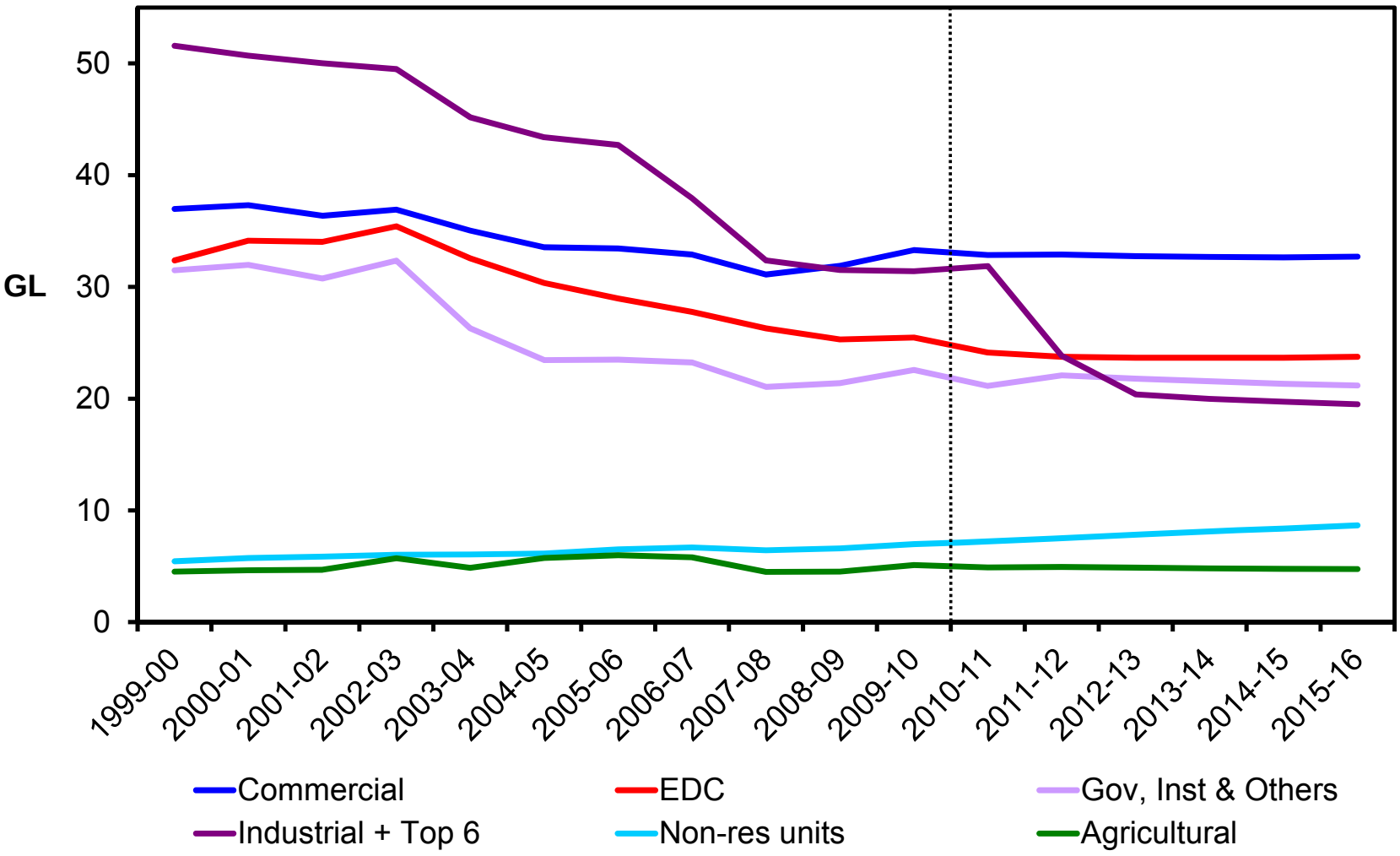


Includes unmetered billed water use

Industrial water use



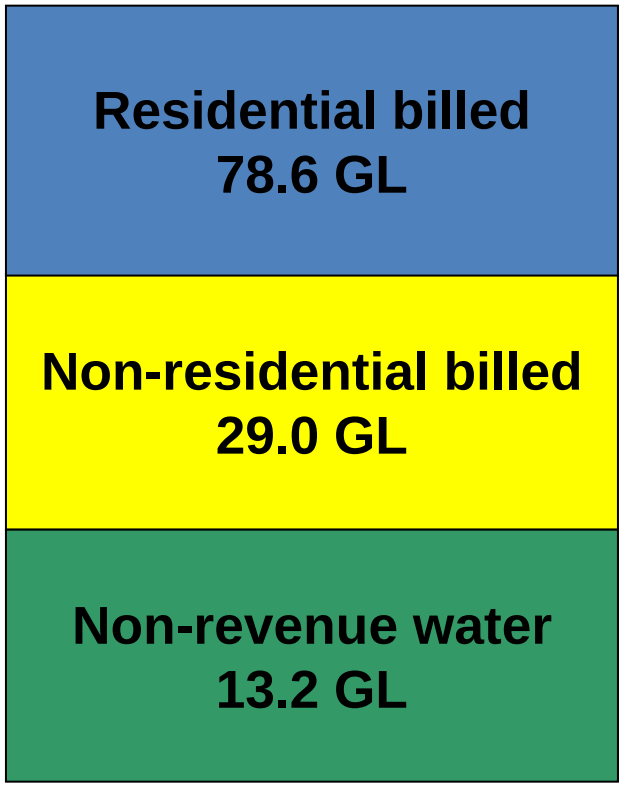
Non-residential – by segment



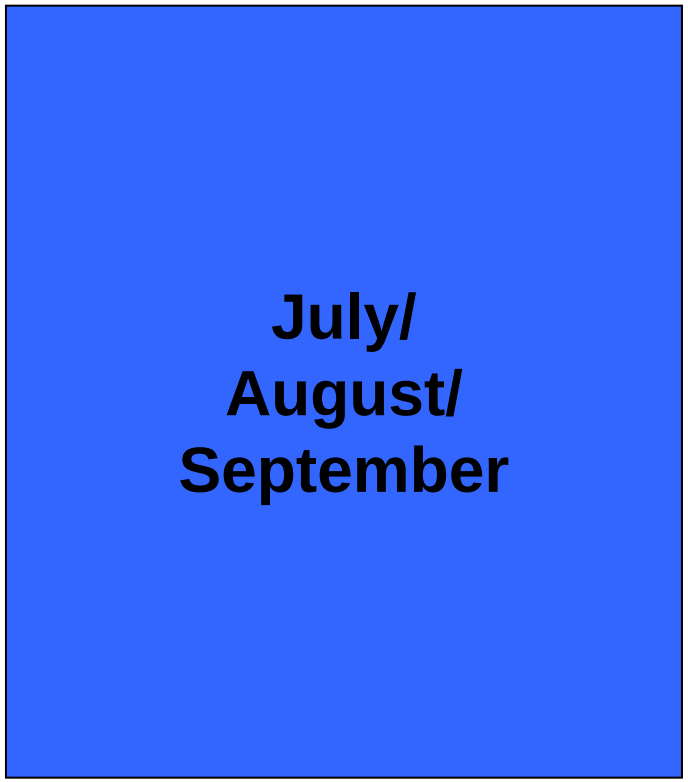
Q1 2011-12 forecast & actual

Updated for actual weather conditions and recycling

120.8 GL (forecast)



119.9 GL (actual)



*** Forecast +0.9 GL or +0.7%, 27 months post Water Wise Rules**

Peer review

Peer review

Sapere Research Group

- Engaged to undertake an assessment of the overall approach and outcome

Price elasticity work (residential modelling)

- WSAA Workshop
- Productivity Commission (presentations/follow up questions)
- Presentation to IPART & Water Pricing Summitt
- Peer review by the Economic Record (accepted for publication)


Questions?