

## **The Magnitude of Non-Revenue Water in Water Demand Forecasting**

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# **Need to Forecast Future Water Demand**

**A reasonable and acceptable  
water demand forecast is  
critical in water resources  
planning**



# Modeling Water Use in the Real World

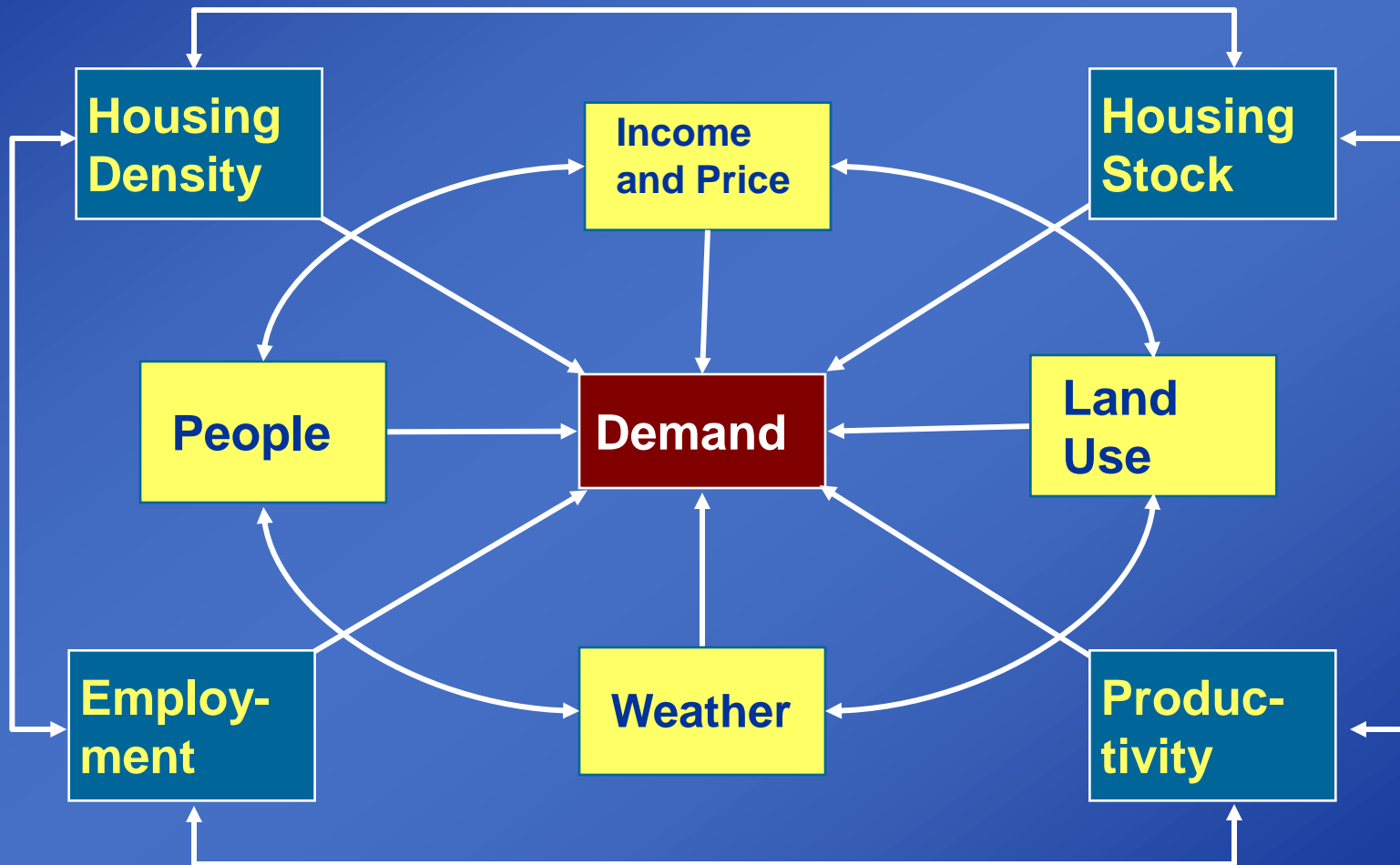


Real World

Observable Relationships

Mathematical Models of Causal Relationships

# Specification and Complexity



# Forecast Development Process

- Step 1: Data collection
- Step 2: Data analysis
- Step 3: Develop water use models
- Step 4: Prepare baseline forecast
- Step 5: Estimate impact of conservation on future water demands
- Step 6: Evaluate sensitivity and uncertainty

# Demand can be disaggregated into sectors and end uses for forecasting

Water Uses			
	Potable	Raw	In-Stream
Sectors	<ul style="list-style-type: none"> <li>■ Residential</li> <li>■ Commercial</li> <li>■ Industrial</li> <li>■ Irrigation</li> <li>■ <i>Unmetered</i></li> <li>■ <i>Unaccounted for</i></li> </ul>	<ul style="list-style-type: none"> <li>■ Agricultural</li> <li>■ Industrial</li> <li>■ Thermopower</li> <li>■ Mining</li> </ul>	<ul style="list-style-type: none"> <li>■ Environment</li> <li>■ Hydropower</li> <li>■ Recreation</li> <li>■ Navigation</li> </ul>
End Uses	<ul style="list-style-type: none"> <li>■ Toilets</li> <li>■ Showers</li> <li>■ Washing Machines</li> <li>■ Faucets</li> <li>■ Landscaping</li> <li>■ Cooling</li> <li>■ Process Water</li> <li>■ Swimming Pools</li> </ul>	<ul style="list-style-type: none"> <li>■ Crop Irrigation</li> <li>■ Livestock</li> <li>■ Cooling</li> <li>■ Boiler Feed</li> <li>■ Process Water</li> <li>■ Conveyance</li> <li>■ Extraction</li> </ul>	<ul style="list-style-type: none"> <li>■ Wildlife Habitat</li> <li>■ Power Generation</li> <li>■ Fishing</li> <li>■ Rafting</li> <li>■ Barges</li> <li>■ Downstream Flows</li> </ul>

# Water Demand Forecast Approaches

Trend  
Extrapolation

Per  
Capita

Unit  
Use

Econometric

*Low*

**Cost & Complexity**

*High*



# Water Demand Forecast Approaches

Trend  
Extrapolation

Per  
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Unit  
Use

Econometric



# Driver Times Rate of Use Approach

Water Use (Q) =

Average Rate of Use  
(q = unit use)

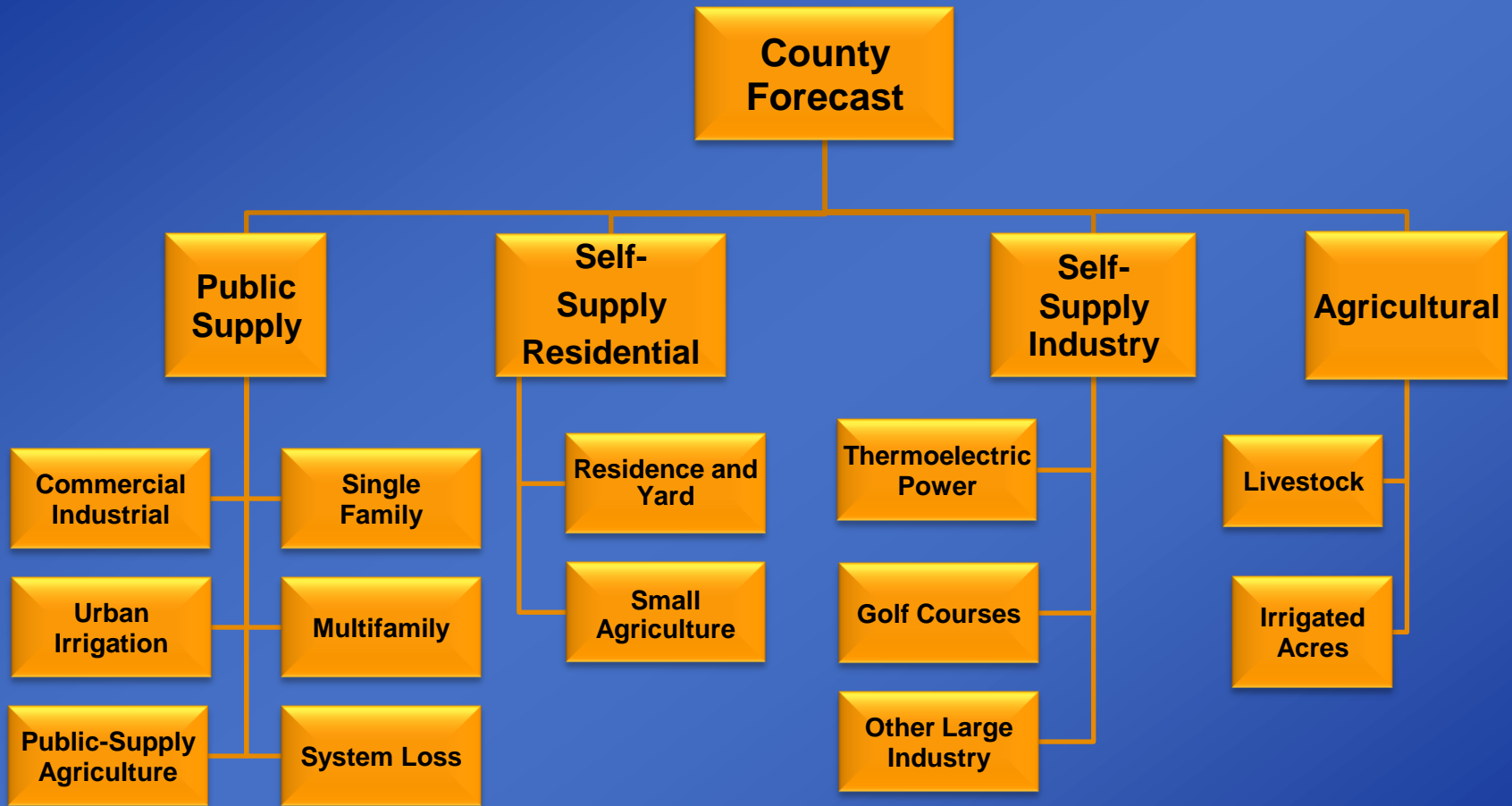
X

Number of Users  
(N = drivers)

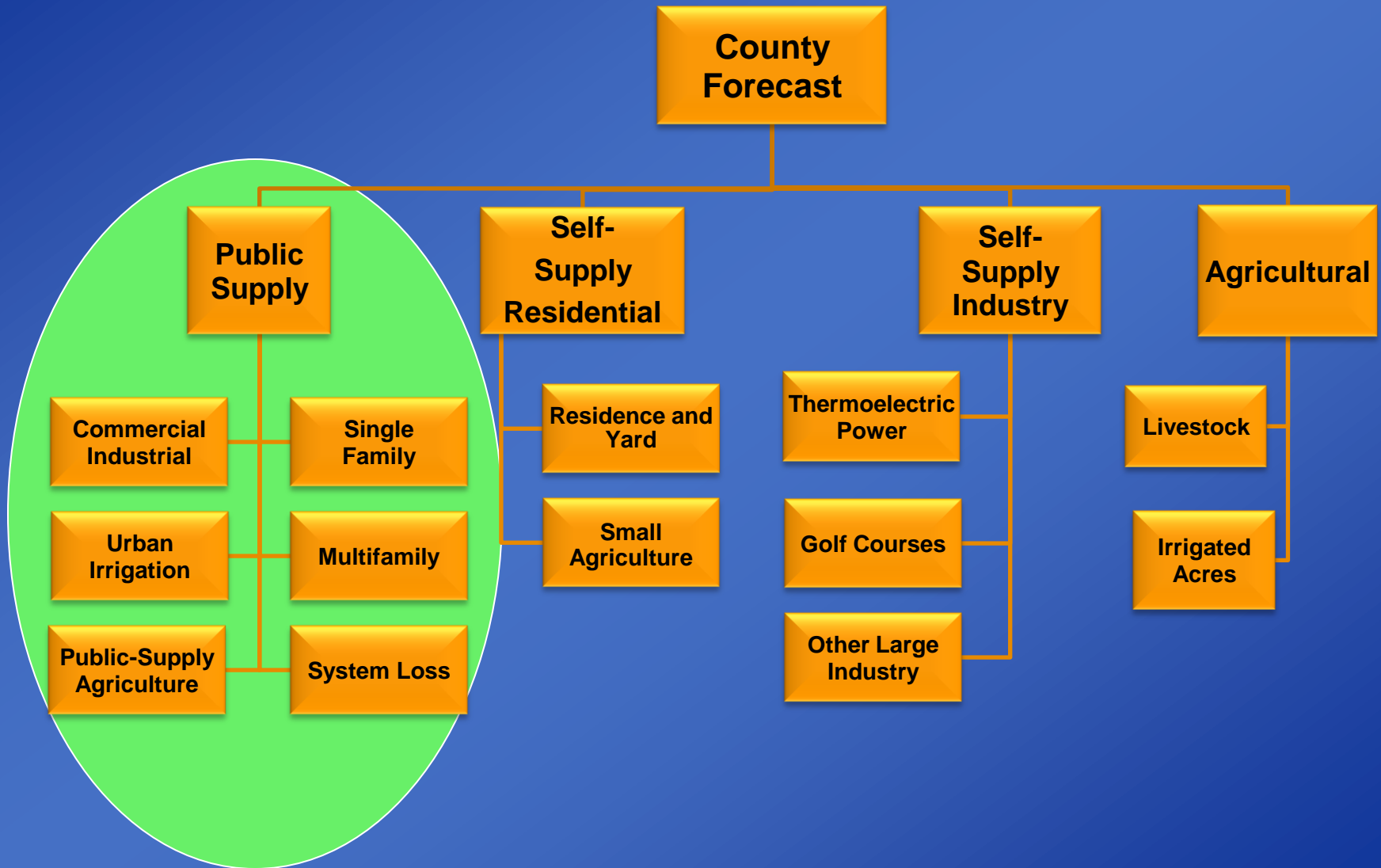
- per person
- per household
- per employee
- per account
- per acre
- per square foot

- Residents or population
- housing units
- employment
- accounts
- acres
- square footage

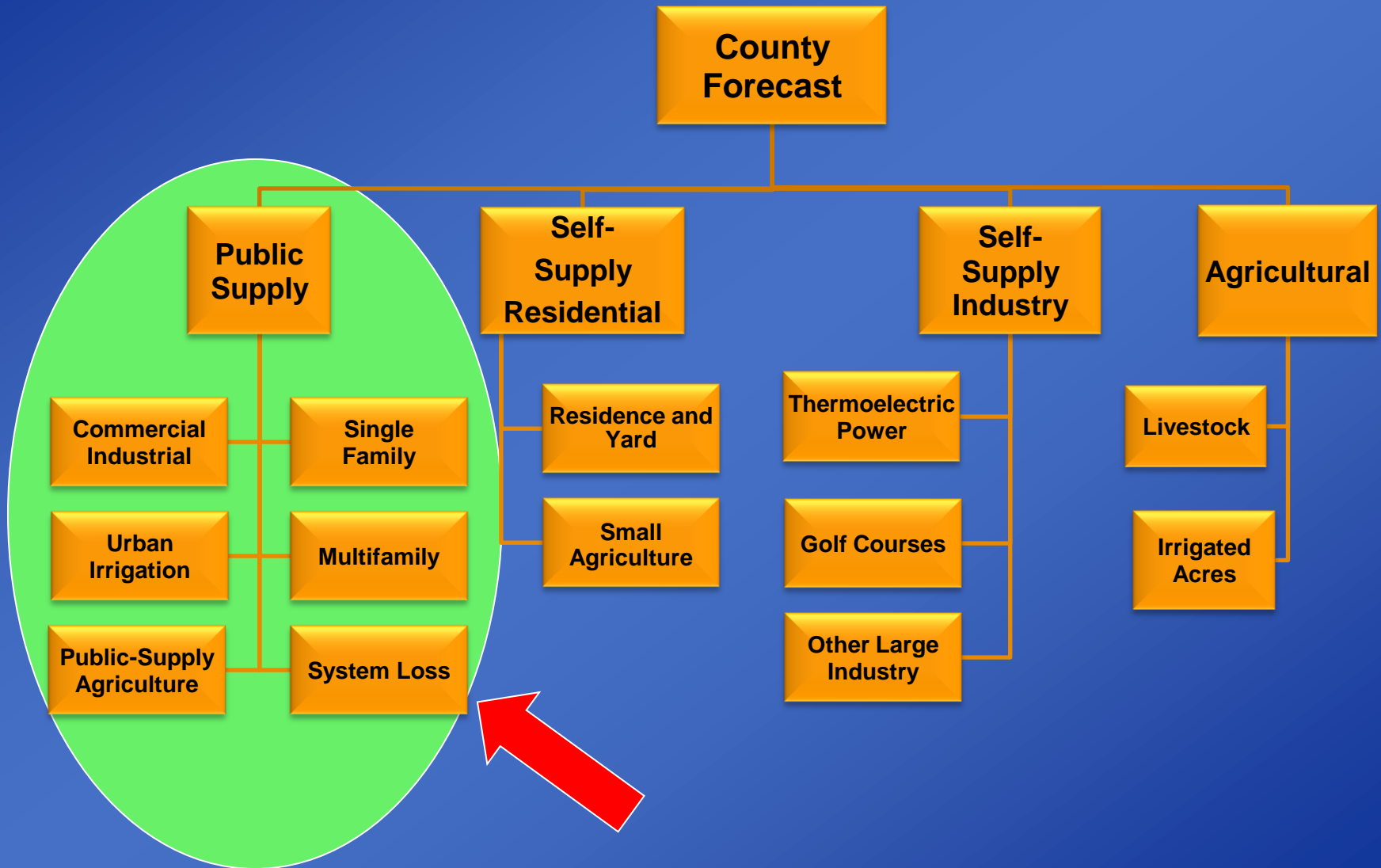
# County Forecast by Sector



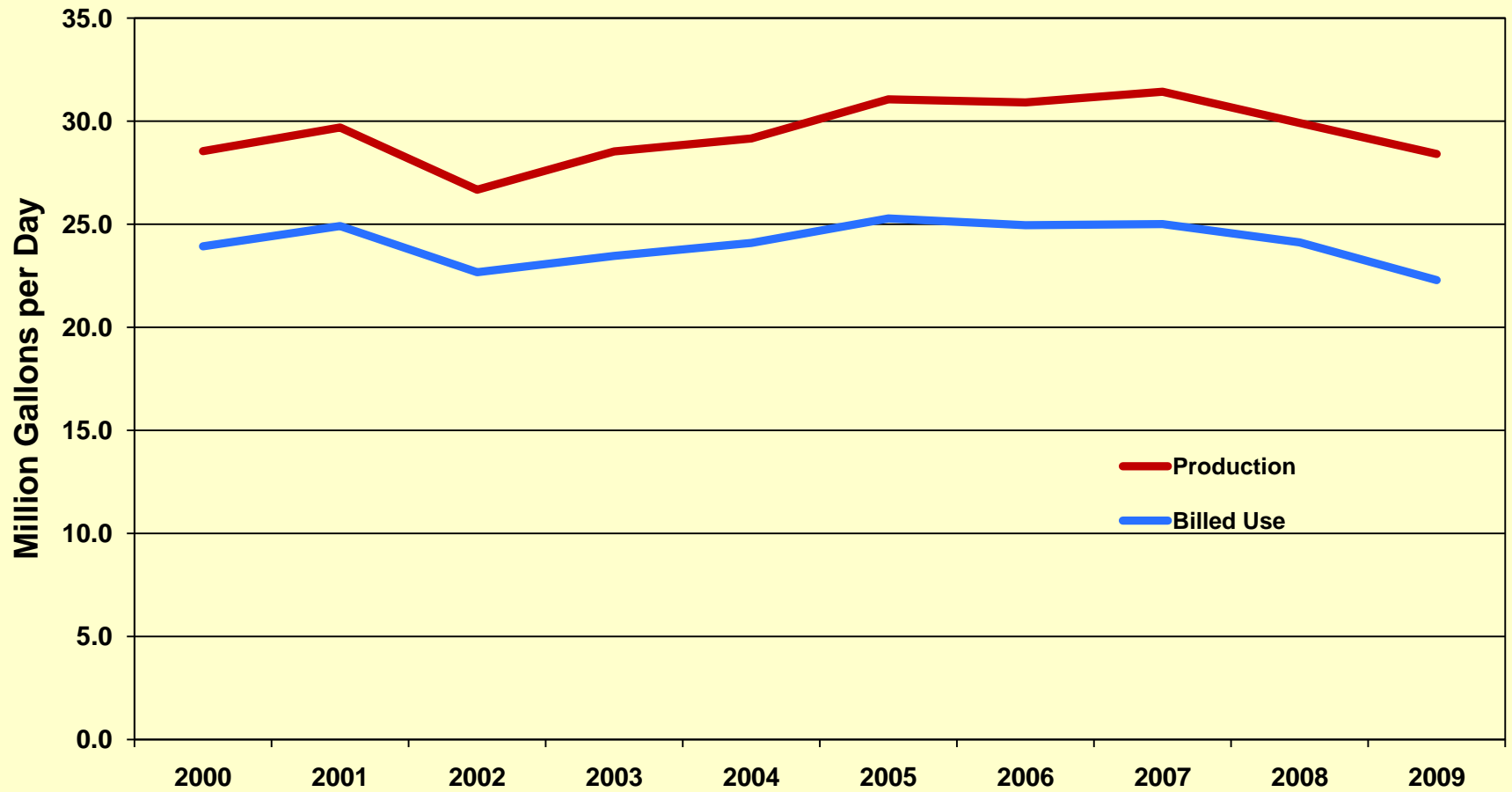
# Focus on Water Supply Systems



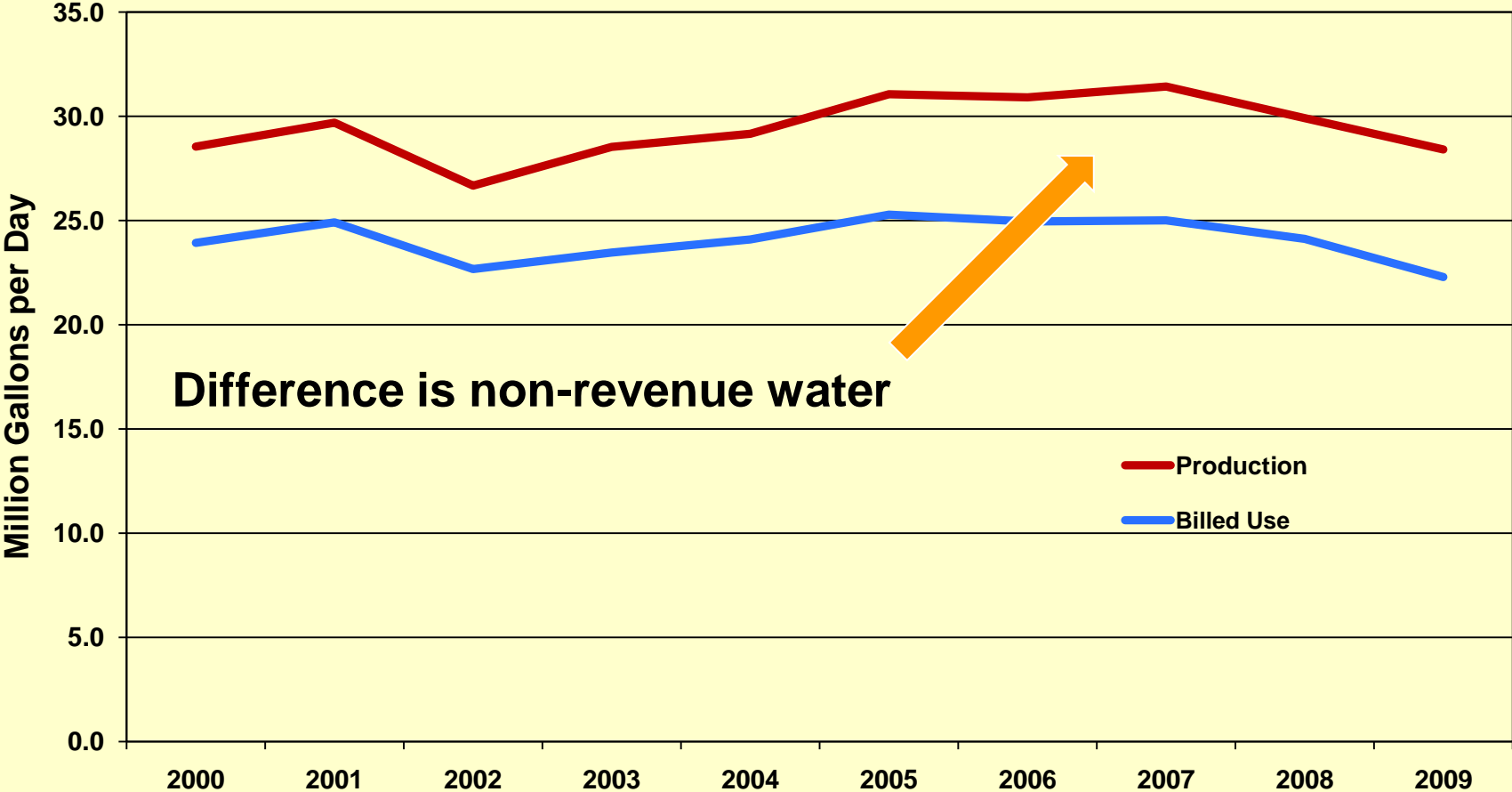
# Focus on Water Losses in System



## Production and Billed Use in MGD



# Production and Billed Use in MGD



# **International Water Association (IWA) Water Audit Format**

- IWA proposed the term 'Non-Revenue Water' (NRW) to replace the term 'Un-Accounted for Water' (UAW).
- The difference between Production and Billed Consumption may include wholesale water sales and authorized unbilled water use.
- Alegre H. et al. 2000, Manual of Best Practice: Performance Indicators for Water Supply Services. IWA Publishing, London.
- Adopted by American Water Works Association, AWWA Journal, August 2003.

Own water sources	System input	Exported water	Authorized consumption	Billed consumption	Revenue water	Billed water exported
		Water supplied		Water losses	Unbilled consumption	Non-revenue water
Billed unmetered consumption						
Apparent losses					Real losses	
			Unbilled unmetered consumption			
			Unauthorized consumption			
Imported water		Source: Alegre H. et al. IWA 2000.				
	Leakage on mains					
	Leakage and overflow at storage					
						Leakage on service connections

Own water sources	Production	Exported water	Authorized consumption	Billed consumption	Revenue water	Billed water exported	
		Water supplied				Billed metered consumption	
						Billed unmetered consumption	
				Water losses	Apparent losses	Non-revenue water	Unbilled metered consumption
		Unbilled unmetered consumption					
		Unauthorized consumption					
Imported water	System input					Meter inaccuracies and data errors	
						Real losses	Leakage on mains
							Leakage and overflow at storage
						Leakage on service connections	

Own water sources	Production	Exported water	Authorized consumption	Billed consumption	Revenue water	Billed water exported
		Water supplied				Unbilled consumption
Billed unmetered consumption						
Water losses	Apparent losses		Unbilled metered consumption			
			Unbilled unmetered consumption			
	Real losses	Non-revenue water	Unauthorized consumption			
Meter inaccuracies and data errors						
Leakage on mains						
Imported water	System input					Leakage and overflow at storage
						Leakage on service connections

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						Billed unmetered consumption
			Apparent losses	Unauthorized consumption		
		Imported water	System input	Water losses	Real losses	Non-revenue water
Meter inaccuracies and data errors						
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# Unbilled Consumption

- Authorized water use
- Does not generate revenue
- Unbilled metered use
  - e.g., schools, government buildings
- Unbilled unmetered use
  - e.g., system flushing, street cleaning, firefighting
- Reducing unbilled consumption increases revenues at some cost

Own water sources	System input	Exported water	Authorized consumption	Billed consumption	Revenue water	Billed water exported		
		Water supplied		Water losses		Unbilled consumption	<b>Non-revenue water</b>	Billed metered consumption
						Apparent losses		Billed unmetered consumption
			Real losses		Unauthorized consumption			
		Imported water		Meter inaccuracies and data errors				
				Leakage on mains				
Leakage and overflow at storage								
					Leakage on service connections			

# Apparent Loss

- Actual water use that is not accounted for
- Does not generate revenue
- Meter errors
- Billing errors
- Unauthorized connections
- Can be reduced through
  - Meter testing & replacement
  - Accurate billing & data control
  - Control of unauthorized use
- Should become billed metered use
- Reducing apparent loss increases revenues at some cost

Own water sources	System input	Exported water	Authorized consumption	Billed consumption	Revenue water	Billed water exported		
		Water supplied		Water losses	Unbilled consumption	Non-revenue water	Billed metered consumption	
					Apparent losses		Billed unmetered consumption	
			Real losses		Unbilled metered consumption			
		Imported water	Water supplied	Water losses	Real losses		Non-revenue water	Unbilled unmetered consumption
								Unauthorized consumption
Meter inaccuracies and data errors								
Imported water	Water supplied	Water losses	Real losses	Non-revenue water	Leakage on mains			
					Leakage and overflow at storage			
					Leakage on service connections			

# Real Loss

## ■ Reported leaks

- Visible leaks, broken mains
- Can be quickly repaired
- Short duration loss

## ■ Unreported leaks

- Not visible at the surface
- Detected through line surveys
- Sustained loss, therefore larger volume

## ■ Background leaks

- Small leaks at joints and fittings
- Not cost-effective to repair

# Performance Metrics

- **UARL: Unavoidable Annual Real Loss**
  - Theoretical minimum leakage on a well-run system
  - Calculated as a function of system pressure, number of connections and miles of pipe
- **ILI: Infrastructure Leakage Index**
  - Ratio of real loss to UARL
- **ELL: Economic Level of Leakage**
  - Level at which cost of leakage reduction equals cost of water saved

# Additional Performance Metrics

- **NRW Percentage (NRW%)**
  - Ratio of NRW to System Input
- **NRW Cost Ratio**
  - Ratio of annual cost of NRW to annual system costs

# Example of a Water Demand Forecast with NRW Management

## Base year water use by sector

Sector	MGD	Percent
Residential	124.5	
Nonresidential	58.0	
<u>Other Retail</u>	<u>2.2</u>	
Total Retail	184.7	57.9%
<u>Wholesale</u>	<u>64.9</u>	<u>20.3%</u>
Total Billed	249.6	
<u>NRW</u>	<u>69.4</u>	<u>21.8%</u>
Production	319.0	100%

# Non-Revenue Water Management

	Current	Target
Unbilled	0.24%	0.24%
Apparent Loss	8.34%	8.00%
<u>Real Loss</u>	<u>13.18%</u>	<u>4.00%</u>
NRW	21.76%	12.24%

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Real loss target is  $ILI = 3.0$



# Non-Revenue Water Management

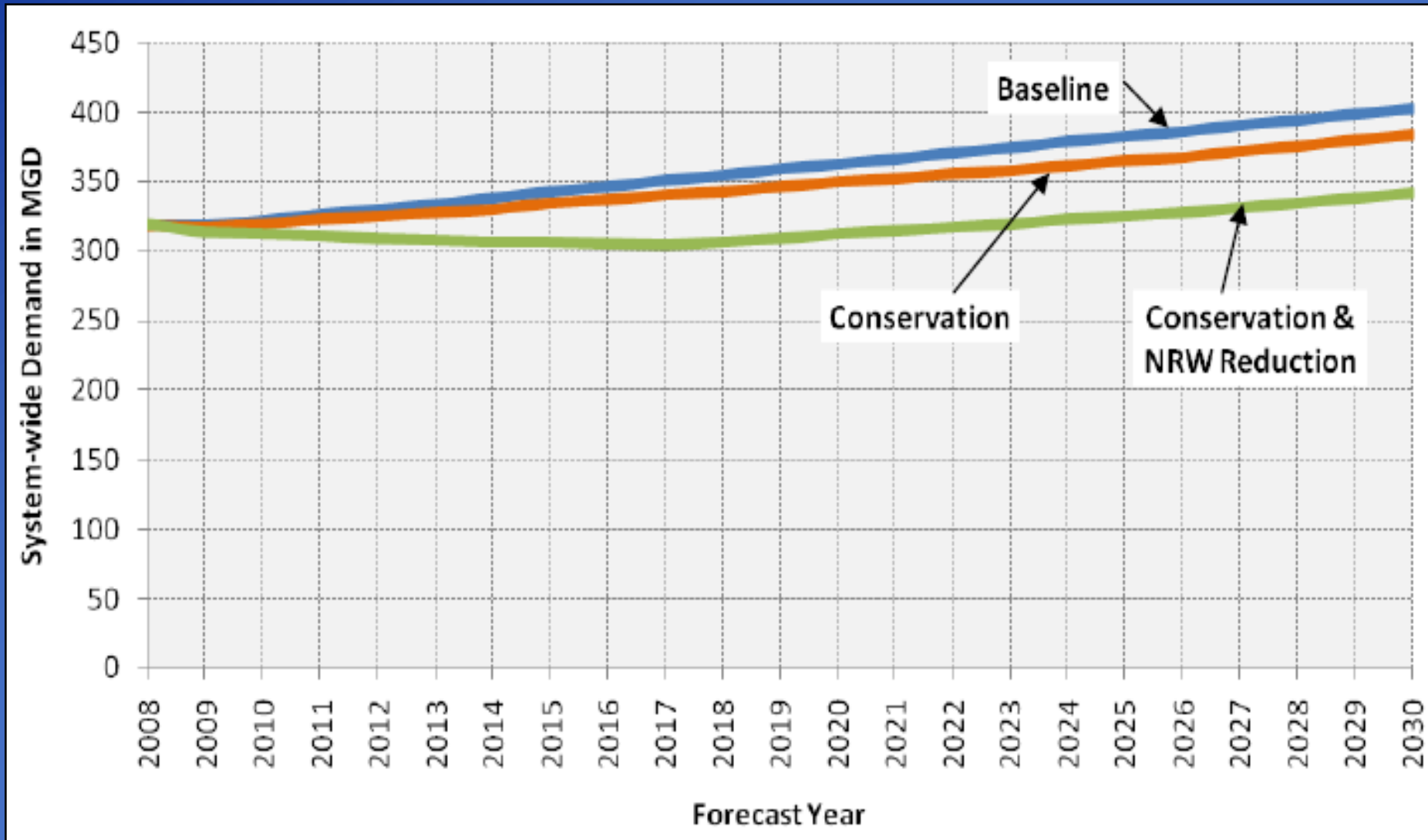
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**Real loss target is ILI = 3.0**

**Calculate NRW volume using both current and target percentages to estimate savings from NRW management**

Forecasts		2008	2010	2015	2020	2025	2030
<b>Total Water Sold from Retail and Wholesale (MGD)</b>	<b>Baseline with Conservation</b>	<b>249.57</b>	<b>250.48</b>	<b>261.61</b>	<b>273.31</b>	<b>285.03</b>	<b>299.82</b>
<b>NRW %</b> Constant { Reduced {	Constant NRW Percent	21.76%	21.76%	21.76%	21.76%	21.76%	21.76%
	Apparent Loss Percent	8.34%	8.34%	8.34%	8.34%	8.34%	8.34%
	Real Loss Percent	13.18%	13.18%	13.18%	13.18%	13.18%	13.18%
	Unbilled Percent	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%
	Reduced NRW Percent	21.76%	19.64%	14.50%	12.37%	12.28%	12.24%
	Apparent Loss Percent	8.34%	8.31%	8.22%	8.13%	8.04%	8.00%
	Real Loss Percent	13.18%	11.14%	6.04%	4.00%	4.00%	4.00%
	Unbilled Percent	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%
<b>NRW Volume (MGD)</b>	Constant NRW % Applied to Baseline Demand After Conservation	69.4	69.7	72.8	76.0	79.3	83.4
	Reduced NRW % Applied to Baseline Demand After Conservation	69.4	61.4	44.4	38.6	39.9	41.8
<b>Savings from NRW Reduction (MGD)</b>		<b>0.0</b>	<b>8.3</b>	<b>28.4</b>	<b>37.4</b>	<b>39.4</b>	<b>41.6</b>

# Forecast with Conservation and NRW Reduction



# Summary

- IWA format identifies measurable components of system loss
- Each component can be addressed separately in a demand forecast
- Each component can be managed at some cost
- Reducing unbilled use and apparent loss increases revenue
- Goal is to maximize revenue and minimize NRW
- NRW management is an important part of sustainable water resource management

**Questions**

**Thank you**

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