

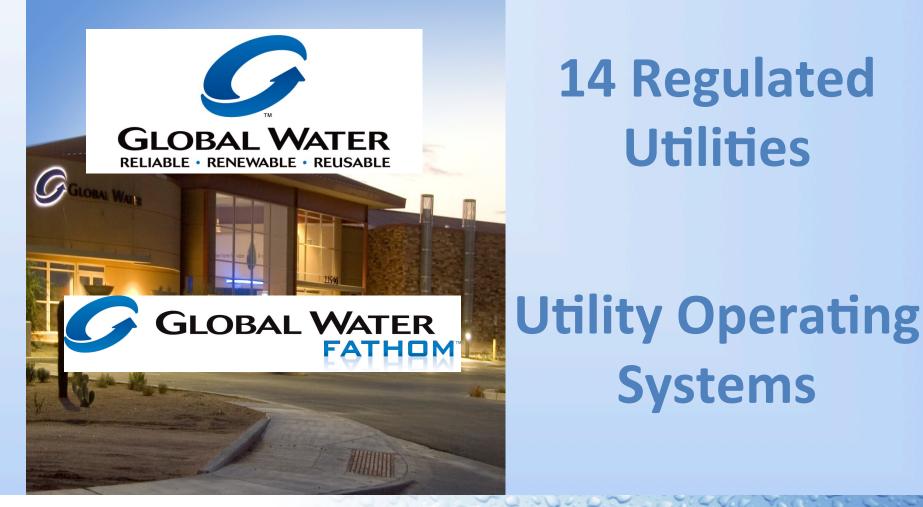
#### Canada Arizona Business Council

### The Challenge of Sustainability

Graham Symmonds Global Water 8 June 2012

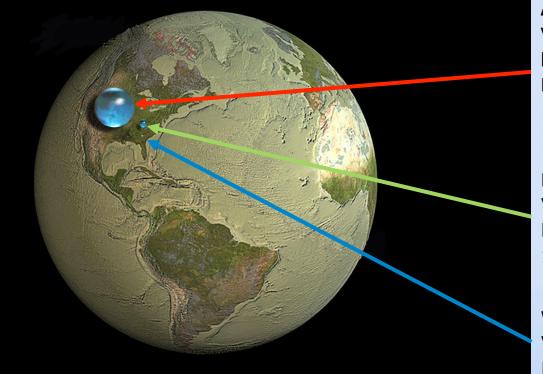


#### **About Global Water**





#### Where's the Water?



ALL OF EARTH'S WATER Volume = 332,500,000 m3 (1,386,000,000 km3) Diameter = 860 miles (1,400 km)

#### LIQUID FRESH WATER

Volume = 2,551,100 mi3 (10,633,450 km3) - 99 % is groundwater, Diameter = 169.5 miles (272.8 kilometers).

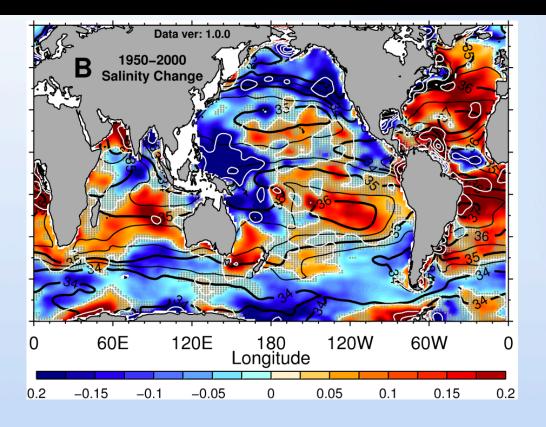
#### WATER IN LAKES AND RIVERS

Volume = 22,339 mi3 (93,113 km3). Diameter = 34.9 miles (56.2 kilometers).

Credit: Howard Perlman, USGS; globe illustration by Jack Cook, Woods Hole Oceanographic Institution (©); <a href="http://ga.water.usgs.gov/edu/2010/gallery/global-water-volume.html">http://ga.water.usgs.gov/edu/2010/gallery/global-water-volume.html</a>



# The Water Cycle is Speeding Up



"In a future GHG-forced 2° to 3°C warmer world, this implies a 16 to 24% amplification of the global water cycle will occur."

"The faster water cycles, the more abundant and more violent those storms might be. And wet places getting wetter can lead to more severe and more frequent flooding. Dry places getting drier would mean longer and more intense droughts."

Source: Durack & Wijffels, Journal of Climate, 2010 (CSIRO)

Paul J. Durack et al, Ocean Salinities Reveal Strong Global Water Cycle Intensification During 1950 to 2000 Science 336, 455 (2012) R. Kerr, "The Greenhouse Is Making the Water-Poor Even Poorer", SCIENCE VOL 336 27 APRIL 2012



#### **Water Scarcity**





## Water Sustainability

#### POLICYFORUM

Climate change undermines a basic assumption that historically has facilitated management of

#### UMATE CHANGE Stationarity Is Dead: Whither Water Management?

C. D. Milly.<sup>1</sup>\* Julio Betancourt<sup>2</sup> Malin Falkenmark.<sup>3</sup> Robert M. Hirsch.<sup>4</sup> Zbigniew W ndzewicz<sup>5</sup> Dennis P. Lettenmaier.<sup>6</sup> Ronald J. Stouffer

hroughout the developed world have een designed and operated under the mption of stationarity. Stationarity-the con nt jath meates in water-SOUT P mplies natany variable (e.g., annual strea flow or annual flood neak) has a time-inv unction (pdf), whose properties can be estiators, or regional or paleohydrolog ata. The pdfs, in turn, are used to evaluate

id manage risks to water supplies, waterorks, and floodplains; annual global invest-

st in uniter in 185001 Ilion 1). iona ity ssu aptic has long mpromises of human disar oances iver basins, Flood risk, water supply, and ater quality are affected by water infraucture, channel modifications, drainage -cover and land-use change a stin es in ing ish ble) so other (s ta or rit ced atur clivate han

infrastructure ency, internal variability (e.g., the ecadal oscillation) enha the slow dynamics of the oceans and ice ets (2, 3). Planners have tools to adjust alvses for known hun in distur rive basins, nd it afte ly ger raily have coiside ed n tur d verificility to be sufficiently all to allow stationarity-based design

used for plann

water supplies, demands, and risks.

that has emerged from climate models (se figure, p. 574). Why now? That anthropogenic climate

change affects the water cycle (9) and water supply 10) is not a new finding. Nevertheless, objections to discarding stationarit we be in raced for a time, by good in a chad to the constable exited the encelope of atura variability analog the effective range of optimally operated infrastructure (11, 12). Accounting for the substantial uncertaintie of climatic parameters estimated from short records (12) effectively hedged as hinst small clima chinges relitional aterior tions ere of co., idered or dible 12 Re ent levelor ents h. e. l. l us

opinion that the time has come to move beyond the wait-and-see approach. Pro jections of runoff changes are bolstered by the recentle demonstated retrodictive skill of climate nodels. The global nattern of observed an ual tre mflo v tr nds s un ike v to haw ariten for unfor eduarit vility incusconsis-tera with modeled response to chimite to jing (15). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (16), although attempts to detect a recent change in globa rapener have been ood

R. Fojec de hang si rune fering to rulti yead lit tim of paje wa er inf struct re projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (19). Some regions have little infrastructure to buffer the pacts of change

Stat one ity cannot e revived Ev a with a gress ve nitigation, con nue I was ning ve litely, wen the side time atmospheric CO, and the thermal inertia of the Earth system (4, 20). A successor. We need to find ways to

identily nonst tionary probabilistic models of col vant em ironm ntal variables and to se these models to optimize we errosten a he halleng i data ting. Patterns of change are complex; uncertainties are narge and the knowledge base changes rapidly. Under the rational planning framework advanced by the Harvard Water Program (21, 22), the assumption of stationarity wa

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Source: Milly, et al, "Stationarity is Dead: Whither Water Management?", Science, 1 Feb 2008

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"The world

challenges

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An uncertain future challenges water planners.

itude ar 1 phiquity of och hat ch ige ap aren y ow y, he wet r, we assert that stations ity unc a dead and should no reager serve as a central default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to chan, ng climate.

w dia stationa use substant I inthe pogeni dead be chan e of F sth's time e i alte ing the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (4, 5) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and ossibly floot rist, where prevailing a no-spheric ware - whore any shore on the generation cel ndues stally heig

ened risk of contamination of coastal fre water supplies. Glacial meltwater temporarilv enhances water availability, but glacier nd snow-pack losses diminish natural seaand international storage (7)

Ar hropog nic lin de warmi ga be friving a polew rd er cans on f the subtropical d v zo e (o), thereby reducing runoff in some regions. Together, circulatory thermodynamic responses largely xplain the picture of regional gainers and losers of ustainable fres water availability

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# Supply-side vs Demand-side

#### **SUPPLY-SIDE**

- Cost: \$\$\$\$\$\$
- Time: Long-term (years)
- Environmental Impact: Negative

#### DEMAND-SIDE

- Cost: \$
- Time: Immediate/Short-term (months)
- Environmental Impact: Beneficial



## **Off-Loading Demand**

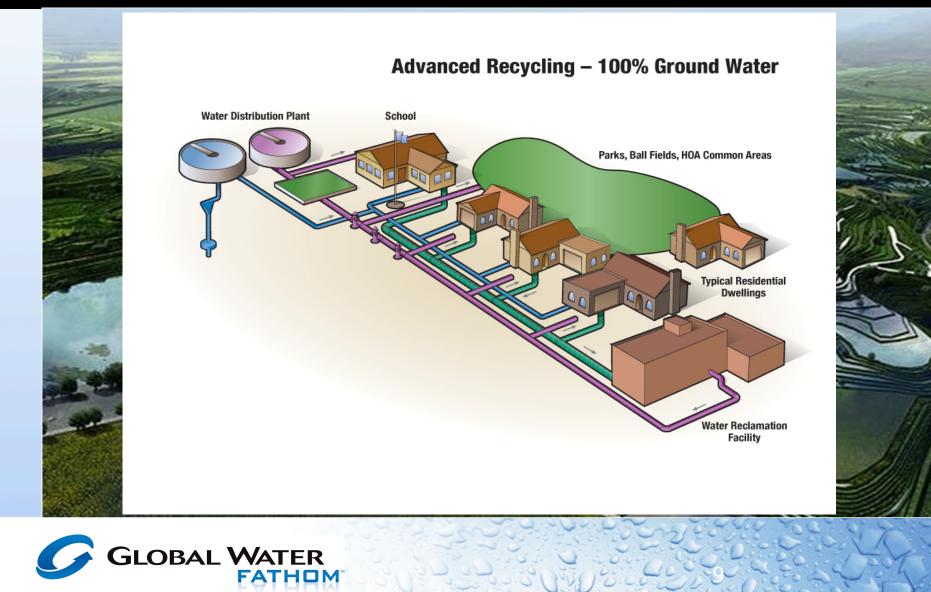


"In the 20th century we built this water system and it brings incredibly high quality potable water to our homes, and we use it to drink and to flush our toilets and to water our lawns. It's a crazy use of a wonderful resource.

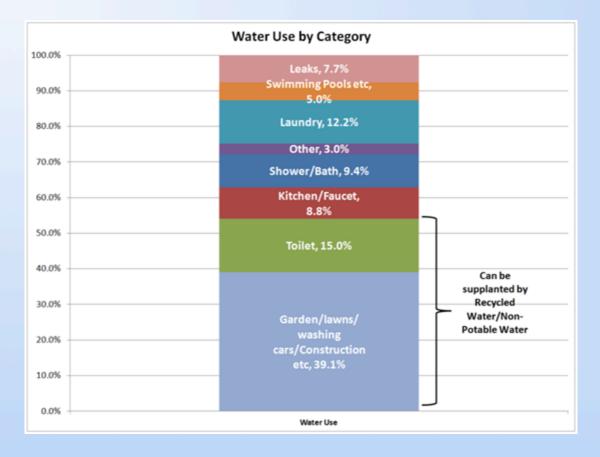
Source: P. Gleick, Fresh Air, WHYY, November 27, 2007



## Infrastructure



## **Off-Loading Demand**





## **Demand-side**

#### "A key to improving efficiency is understanding where, when, and why we use water."

Source: Gleick, P., "Roadmap for sustainable water resources in southwestern North America," PNAS, 14 Dec 2010



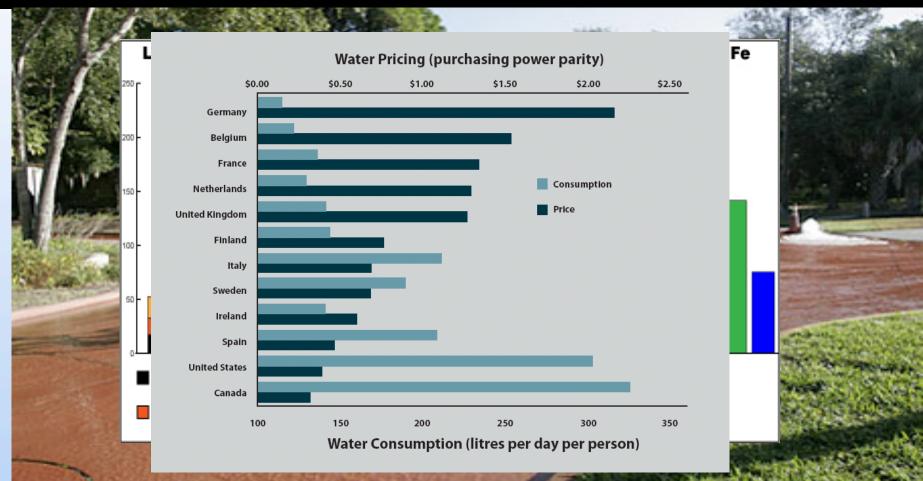
## **Changing Behavior**

[...]interventions that combine appeals, information, financial incentives, informal social influences, and efforts to reduce the transaction costs of taking the desired actions have demonstrated synergistic effects beyond the additive effects of single policy tools.

Source: Dietz, T., Gardner, G., Gilligan, J., Stern, P.C., Vandenbergh, M.P., Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. Proceedings of the National Academy of Sciences, 106(44), pp. 18452-18456, 2009



## Why Rates are Important



Source: Brett Walton "The Price of Water: A Comparison of Water Rates, Usage in 30 U.S. Cities", April 26, 2010, Circle of Blue Source: Oliver M Brandes et al, "Worth Every Penny: A Primer on Conservation-Oriented Water Pricing", POLIS Water Sustainability Project, May 2010



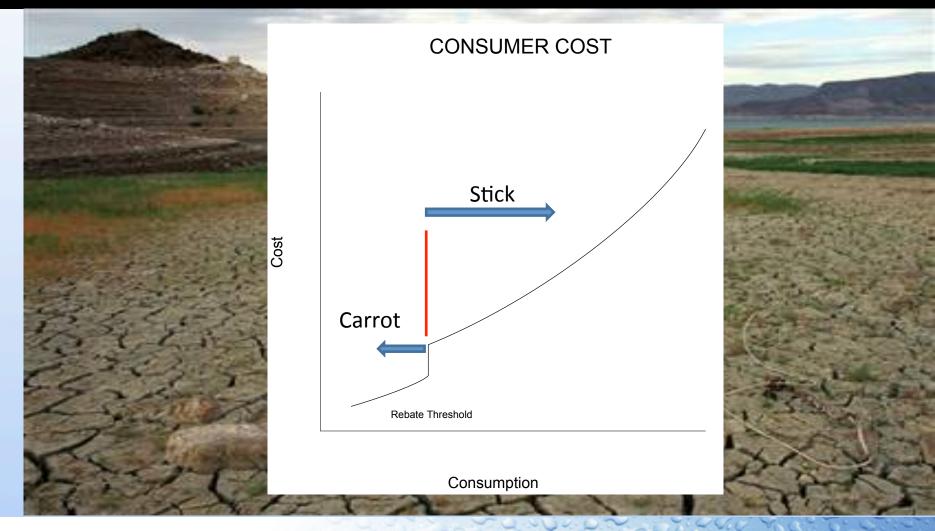
## **The Effect of Rates**

On average, a 10% increase in the marginal cost of water can be expected to reduce residential demand by 3-4% in the short run. In the long term, such an increase could be expected to yield a 6% decrease in demand.

Source: Sheila M. Olmstead and Robert N. Stavins, "Comparing price and nonprice approaches to urban water conservation", 25 April 2009, WATER RESOURCES RESEARCH, VOL. 45, W04301, doi:10.1029/2008WR007227, 2009 p. 4



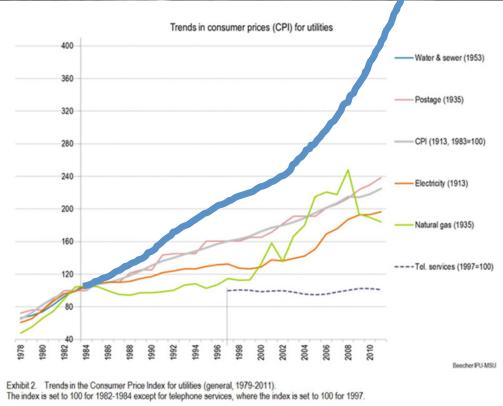
#### **Altering Behavior - Incentives**





#### As Rates Increase...

### People will demand information

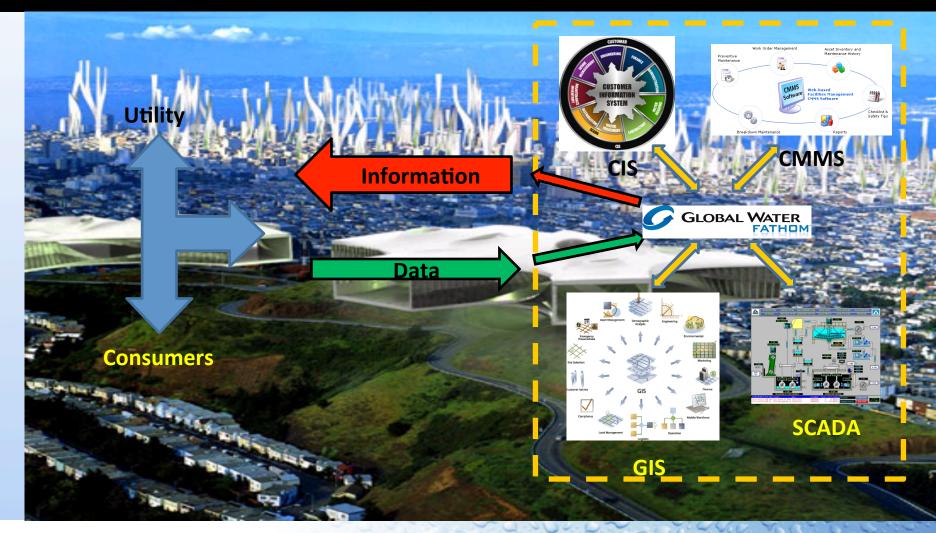




Source: Brett Walton, Circle of Blue, "The Price of Water 2012: 18 Percent Rise Since 2010, 7 Percent Over Last Year in 30 Major U.S. Cities", 10 May 2012



## **Smart Grid for Water**





## The Importance of Data

• AT&T 穼		9:01 AM				77%	
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Water Consumption							
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	Daily Consumption	Weekty Consumption		nthly nsumptio	on		
	This graph shows your <b>Daily Water Consumption</b> , displayed in gallons, as computed from nightly, monthly, or bimonthly mater reads. Your consumption is the blue bir graph. You can asio see how you compare to your neighborhood and your city.						
	1200						
	800						
	400	d di			J		
	200 08/23	08/24 08/25	06/25	08/27	08/28	8/29	
	Your Neighbors Your City						
	Average Consu	mption	Date	You	Neighbors	City	
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	Gallons per Day	/	06/26	119	854	614	
	You are using 72% is	as than others in	06/27	89 403	811 761	546 540	
	your utility.						

"People don't recognize how powerful the pull of the crowd is on them...We can move people to environmentally friendly behavior by simply telling them what those around them are doing."

Source: Simon, S. "The Secret to Turning Consumers Green", Wall Street Journal, 18 October 2010



#### **Personalized Data**



#### How much water do I use?

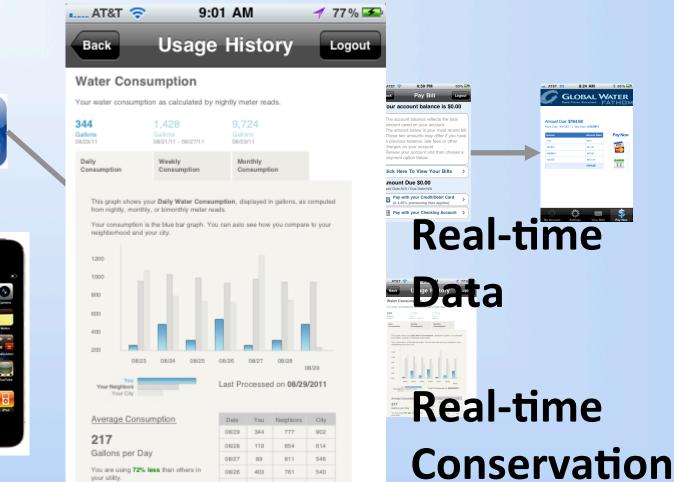
How do I fare compared to my street, my neighborhood, my city?

How much water should I use?

Based on weather data and evapotranspiration calculations – how much should I have used outside?



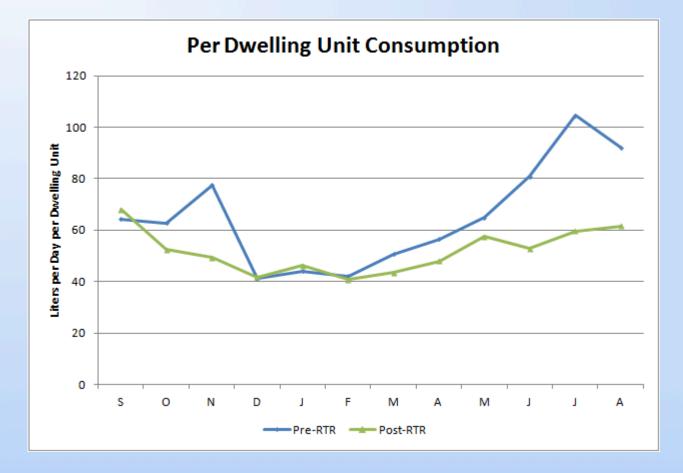
#### Access to Data = Conservation







#### **Incentives and Information**





## **Changing Behavior**

"Truly sustainable water management and use requires efficiency, smart economics, advanced technology and better governance and water management."

Source: Dr. Peter Gleick, "The Real Cost of Water We Use", presented at the Stanford Graduate School of Business, 9 Feb 2010

