NEED TO KNOW

WATER RATES: WATER DEMAND FORECASTING

Water managers forecast future water demand for a variety of purposes. These analyses can help managers understand spatial and temporal patterns of future water use to optimize system operations, plan for future water purchases or system expansion, or for future revenue and expenditures. There are several mathematical methods in use for estimating future demand; these include extrapolating historic trends, correlating demand with socio-economic variables, or more detailed simulation modeling. Models vary in complexity according to the number of variables and the extent to which water users are disaggregated by sector, location, season, or other factors. Models also vary according to the forecast horizon. Long-term forecasting is typically more useful for infrastructure and capital planning whereas short-term forecasts are more useful for setting water rates (Table 1).

The simplest and most traditional means of forecasting future water demand has been to estimate current per-capita water consumption, usually measured as gallons per capita per day (gpcd), and multiply this by expected future population.[i] Population estimates may be based on simple linear growth, a percent annual increase (exponential growth), or more detailed analyses by demographers or forecasters. This simple approach has drawbacks, as it does not account for changes in technology, the economy, or culture over time.

More detailed models may take into account a wide variety of factors, such as changes to population, water prices (e.g., price elasticity); the climate (e.g., weather variability is appropriate for short-term forecasts while global climate models are useful for longer-term forecasts); customer behavior (e.g., increased conservation and efficiency); and new regulations (e.g., the Water Conservation Act of 2009). In our survey of water service providers in California, less than half of respondents indicated that they consider future land uses in the forecasts of future demand or incorporate the impacts of price elasticity on water

IMPORTANCE TO WATER RATES

Although water managers use demand forecasting in a variety of ways, here, we focus on why demand forecasting is important for water rates. Water service providers must anticipate how much water they expect to sell in order to ensure that revenue will cover costs. Water rates are typically only set once every few years, so water agencies must forecast future demand several years in advance to ensure that they collect enough funds.

Table 1. Types of Water-Demand Forecasts and Major Applications (Adapted from Billings and Jones 2008)[ii]

Forecast Type	Forecast Horizon	Applications
Long-Term	Decades	Sizing system capacity, raw water supply
Medium-Term	Years to a decade	Sizing, staging treatment and distribution system improvements
Short-Term	Years	Setting water rates, revenue forecasting, program tracking and evaluation
Very Short-Term	Hours, days, weeks (up to two weeks)	Optimizing, managing system operations, pumping

Forecasts have historically overestimated water demand. Figure 1 shows actual water demand as compared to water demand forecasts for the Seattle region. While demand forecasts have improved over time (with several more recent forecasts capturing the trend of declining water demand), it is still clear that most forecasts tend to overestimate water demand in the medium- to long-term future.

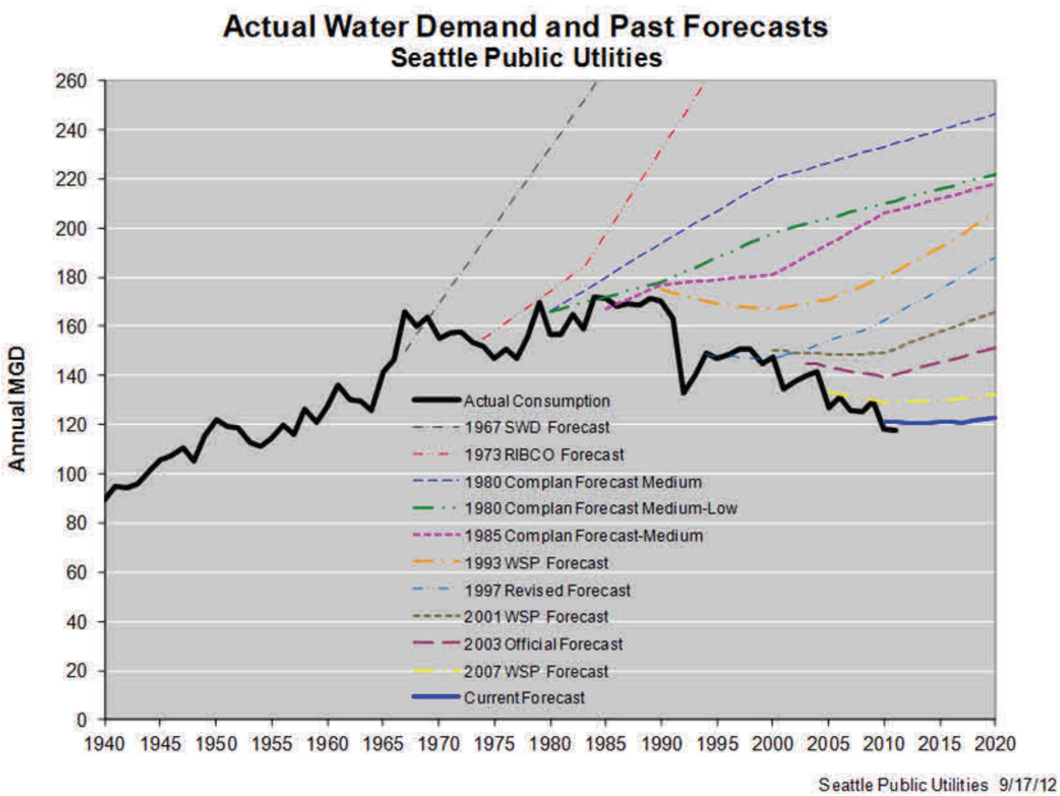

Figure 1. Water Demand and Past Forecasts for Seattle Public Utilities (Flory 2012)[iii]

Inaccurate results can impact the financial stability of a water service provider, particularly if the rate structure is sensitive to demand variability (for example, low fixed charges, high volumetric charges, steeply inclined tiers, or seasonal rates). If the rate structure makes revenue less sensitive to demand variability (for example, high fixed charges, declining tiers, or a flat rate), a good demand forecast is less important, though it can still be useful for projecting costs.

STRATEGIES FOR SUCCESS

Consider a Range of Explanatory Variables

In 2008, the American Water Works Association surveyed water systems in the United States and found that most agencies that forecast demand used the simplest of all methods: multiply future population estimates by historical per capita water use.[iv] This is a relatively straight-forward way to conduct demand forecasting; however, it is limited because it does not incorporate important variables that impact demand, including new legislation, conservation programs, demographic changes, and climate change. Forecasts that rely only on historic conditions, are not likely to accurately reflect a changing future.

Include 20x2020 Targets

While some changes are impossible to predict, others can be anticipated and fairly accurately estimated. For instance, the impact of new efficiency standards can be evaluated using a number of widely-available tools. Water service providers may consult their local planning and finance departments to understand how drivers of water demand are expected to change in the future; for example, new industries and residential housing developments will increase water use in those sectors. Demand response from conservation programs or new efficiency standards should also be included in the forecasts. At a minimum, all water service providers in California should incorporate 20x2020 targets (20% per capita water conservation by 2020 required by the Water Conservation Act of 2009) into demand forecasts.

Include Price Effects

Most demand forecasts do not take into account the impact of price on demand. The assumption that per capita water demand remains constant in the future implies zero price response, which is hardly ever the case[v]. Indoor water demand is generally considered less elastic,[vi] yet it has decreased over time in California for a number of reasons. Outdoor water use, by contrast, is more elastic as it contains a larger "discretionary" component, such as landscape watering and pools, and customers are more likely to cut down in response to higher prices.[vii] Thus, it is prudent to consider the demand response to changes in water prices over time.[viii]

Utilize Existing Software

Several programs exist to help utilities predict the effects of conservation programs on demand (Table 2). For example, members of the California Urban Water Conservation Council have access to the *Demand Side Management Least Cost Planning Decision Support System Model* for medium- to long-term forecasting and the *Cost Effectiveness Analysis Tool* for short-term forecasts. In addition, members of the Alliance for Water Efficiency have access to the *Water Conservation Tracking Tool*, which allows water service providers to project future conservation and passive water savings. Finally, the Pacific Institute offers a free, spreadsheet-based model that can be downloaded online. The *Urban Water Demand to 2100* model is useful for long-term forecasts, allowing users to analyze effects of climate, population, prices, and technology on urban water demand in California through year 2100.

Table 2. A Selection of Existing Software for Estimating Future Water Demand and the Impact of Water Conservation and Efficiency on Demand

Software Name	Applications	Source
IWR-MAIN*	The Forecast Manager can assist water planners in projecting future water demands for municipal and industrial uses. The Conservation Manager can assist water planners in forecasting water demand and analyzing water conservation at the end-use level.	www.cdmsmith.com
Demand Side Management Least Cost Planning Decision Support System**	Provides 30-year water demand forecasts, 30-year water conservation forecasts, and 30-year benefit-cost ratios of conservation measures and programs.	www.cuwcc.org/resource-center/technical-resources/bmp-tools.aspx
Water Conservation Tracking Tool	Develops forecasts of the water savings related to long-range conservation plans, constructs conservation portfolios containing up to 50 separate conservation program activities.	www.allianceforwaterefficiency.org/Tracking-Tool.aspx
California Urban Water Demand to 2100	Provides long-term forecasts of urban water demand, allows users to analyze effects of climate, population, prices, and technology on urban water demand in California through 2100.	www.pacinst.org/reports/urban_water_demand_2100

Notes:
* indicates software only available to paying customers
** indicates software that is only available to paying customers or members of the California Urban Water Conservation Council

Conduct Sensitivity Analyses

Most demand forecasting models are deterministic and show a single estimate of future consumption. Probabilistic models, by contrast, produce a range of outputs rather than a single output. Even with deterministic models, a sensitivity analysis can help understand how the uncertainty in input parameters affects demand estimates. For example, instead of calculating a single forecast using a population growth rate of 1% per year, the analyst may run the model several times, with growth rates varying from 0.5% to 1.5%. Such an analysis demonstrates the *sensitivity* of the model, or how the result changes in response to this one variable. These methods are especially useful where a parameter is highly uncertain or a range of possible values are equally likely (for instance, when projecting future growth). Sensitivity analyses help water planners evaluate the relative impact of different management decisions.

ENDNOTES

[i] McMahon, T.A. 1993. “Hydrologic Design for Water Use.” In: *Handbook of Hydrology*. McGraw-Hill Professional.
[ii] Billings, R.B. and C.V. Jones. 2008. *Forecasting Urban Water Demand*. Denver, CO: American Water Works Association.
[iii] Flory, B. 2012. Personal Communication. Principle Economist, Seattle Public Utilities.
[iv] Billings, R.B. and C.V. Jones. 2008. *Forecasting Urban Water Demand*. Denver, CO: American Water Works Association.
[v] Chesnutt, T.W., J.A. Beecher, P.C. Mann, D.M. Clark, W. M Hanemann, G.A. Raftelis, C.N. McSpadden, D.M. Pekelney, J. Christianson, and R. Krop. 1997. *Designing, Evaluating, and Implementing Conservation Rate Structures, A Handbook for the California Urban Water Conservation Council*. Santa Monica, CA: California Urban Water Conservation Council.
[vi] Olmstead, S. M. and R. N. Stavins. 2009. “Comparing Price and Nonprice Approaches to Urban Water Conservation.” *Water Resources Research* 45 (4): W04301.
[vii] *Ibid.*
[viii] Christian-Smith, J., M. Heberger, and L. Allen. 2012. *Urban Water Demand in California to 2100: Incorporating Climate Change*. Oakland, CA: Pacific Institute. http://pacinst.org/reports/urban_water_demand_2100/full_report.pdf.