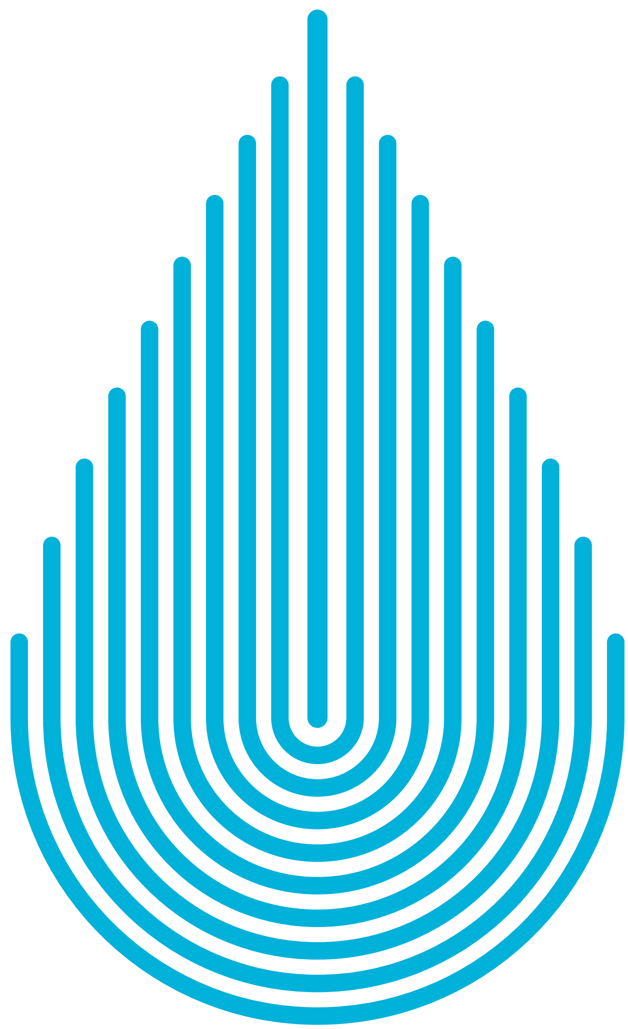
Ceres

The Ripple Effect:

WATER RISK IN THE MUNICIPAL BOND MARKET

A Ceres Report
October 2010



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WATER ASSET MANAGEMENT

A FRAMEWORK FOR ASSESSING WATER & ELECTRIC UTILITIES

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ACKNOWLEDGEMENTS

This report was made possible through support from the Walton Family Foundation, the Turner Foundation, the Park Foundation, the Compton Foundation, and Water Asset Management. The opinions expressed in this report are those of the authors and do not necessarily reflect the views of the sponsors.

Ceres wishes to thank the PwC analysts who provided modeling assistance for this report, including Madiha Bakir, Darren Boland, Tania Campbell, Celine Herweijer, Andrew Jones, James Lieu, Elinore O'Neil, Varun Sarda, Jon Williams, and John Woodrow as well as Disque Deane, Jr., Martha Engh, and Richard Onses of Water Asset Management and David Yates from the National Center for Atmospheric Research.

Ceres also wishes to thank the members of the Ceres team who provided valuable insight and assistance: Brooke Barton, Peyton Fleming, Matt Moscardi, Andrea Moffat, Dan Mullen, Susan Burrows, Joe Kwasnic, Berkley Adrio, Amy Augustine, Andrew Gaynor, Jacqueline Calahong, Shutsu Chai, and Warren Paul Anderson.

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The following individuals—bringing a diverse range of expertise in the financial, conservation, legal, hydrological, and water and electric utilities fields—provided valuable input on the model developed in this study to assess utility bond exposure to water risk, and also provided feedback on the draft report.

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FOREWORD BY CERES

If we've learned anything from the recent credit crisis and resulting economic downturn, it's to be concerned about hidden risks in assets owned by major investors across our economy. Growing water scarcity in many regions of the United States is a risk running through municipal bond markets, one that must be addressed if we are to protect the strength of those investments and finance our nation's vast water and power infrastructure.

Water powers our economy, fueling electricity production, manufacturing, agriculture and myriad other activities on which we depend. Many public water supplies in the West, Southwest, and Southeast are already being constrained by dwindling resources and growing demand that, in turn, are fueling regional water conflicts and tighter regulatory controls.

Public water utilities deliver more than 80 percent of the nation's water to residential and industrial consumers and issue billions of dollars' worth of bonds each year to fund infrastructure and ensure continued water delivery. Public electric utilities also depend on ample freshwater to generate hydropower and cool power plant equipment. The municipal bond market depends on accurate assessments of water availability and quality—now and in the future—to understand these utilities' ability to pay back the debt on those bonds.

This report by Ceres, PricewaterhouseCoopers (PwC), and Water Asset Management shows that few participants in the bond market—including investors, bond rating agencies, and the utilities themselves—are accounting for growing water scarcity, legal conflicts and other threats in their analyses. Some are even inadvertently encouraging risk by rewarding pricing and infrastructure plans that encourage increased water use despite near-term supply constraints. By overlooking these critical factors, all involved are allowing water risk to grow—and remain hidden—in the bond market.

At Ceres and through our Investor Network on Climate Risk, we encourage investors to seek environmental risk information that is material to the present and future value of their investments. Investor information depends on full, robust disclosure by those raising capital by issuing bonds and careful analysis by those rating the bonds.

This report includes a first-of-its-kind model, developed by PwC, to aid rating agencies, public utilities and investors in understanding the potential risks of undersupply. We ran the model for eight investment-grade public utility bonds—six water utility bonds and two electric power utility bonds, all for utilities in water-stressed regions—and generated water risk ratings under multiple "stress tests," or water scarcity scenarios.

With these results, investors can begin to understand potential vulnerability to utility systems.

The report offers a detailed set of recommendations for utilities, rating agencies, underwriters and investors to better manage this water scarcity challenge. We hope this report and its recommendations will catalyze conversations and partnerships to develop best practices for understanding, anticipating and, ultimately, reducing water risk in our national investments. We hope in doing so we will better preserve our precious water resources for generations to come.

Mindy Lubber
President, Ceres
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WATER RISK TO PUBLIC UTILITIES AND THEIR INVESTORS

Water is a linchpin of the U.S. economy, but its availability is being tested like never before. More extreme droughts, surging water demand, pollution, and climate change are growing risks that threaten water supplies in many parts of the United States. In some regions, water scarcity is already crimping economic production and sparking interstate legal battles. The stresses are especially severe in regions experiencing rapid population and economic growth, including the West, Southwest and Southeast. Among the most immediate threats:

- The City of Atlanta's water supply could be cut by nearly 40 percent as early as 2012 due to the ruling of a federal judge;
- Lake Mead, the vast reservoir for the Colorado River, is quickly approaching a first-ever water shortage declaration that would reduce deliveries to fast-growing Arizona and Nevada;
- Hoover Dam, which provides hydropower to major urban centers in California, Arizona, and Nevada, may stop generating electricity as soon as 2013 if water levels in Lake Mead don't begin to recover;[1]
- More regular droughts and heat waves are likely to increase the operating costs of power generators in the Southeast, among them the Tennessee Valley Authority, which was forced to slash power generation for two weeks at three of its facilities in Alabama and Tennessee because of heightened water temperatures, costing the utility an estimated $10 million in lost power production.[2]

These trends have enormous implications for the thousands of *public utilities*—utilities managed by municipalities and counties—that supply water and electricity to households and businesses across the country. Water utilities generate revenue through the delivery of water to their commercial and residential customers. Electric utilities use water for hydropower production or to cool equipment in their generating facilities. The power sector is enormously water-intensive and accounts for 41 percent of the nation's freshwater withdrawals.

1 Eric Wolff, "Hoover Dam could stop generating electricity as soon as 2013, officials fear," *North County Times*, September 11, 2010, http://www.nctimes.com/business/article_b7e44e9e-087d-53b2-9c49-7ea32262c9a9.html

2 Dave Flessner, "TVA cuts plant output," *Chattanooga Times Free Press*, August 3, 2010.

Water Risk to Public Utilities and Their Investors

Investors who provide the vast amount of capital to build and maintain the nation's water and power infrastructure are also threatened by these trends. Municipal bonds—the debt instrument of choice for public utilities—are bought and sold on the basis of their credit ratings. Yet today these ratings take little account of utilities' vulnerability to increased water competition, nor do they account for climate change, which in many areas is rendering utility assets obsolete. Consequently, investors are blindly placing bets on which utilities are positioned to manage these growing risks.

This report will demonstrate why investors should treat water availability as a growing concern for both public water and electric power utilities, and how associated risks are not currently reflected in public utility bond ratings. Because these ratings assess utilities' ability to repay debt, their failure to include growing water risks neglects a key factor essential to the financial viability of utilities—and to the institutional and retail investors who own their bonds.

Water shortfalls can undermine water and electric power utilities' short-term liquidity and financial leverage—key elements of credit risk. Yet water risk "stress tests" and other evaluative measures are not currently being used by ratings agencies.

This report demonstrates that in order for utility bond ratings to convey a public utility's true credit risk, the rating opinion must incorporate the system's vulnerability to water availability risks. Today's credit rating agencies fail to incorporate these metrics consistently, leaving investors with insufficient information for managing their potential exposure in holding such bonds.

The report provides a quantitative framework for evaluating water risks of public utility bonds. Eight investment-grade utility bonds are analyzed in the report, all of them issued by utilities in regions facing water stresses, including California, Texas, Arizona, Alabama, and Georgia.

The report includes specific recommendations for water and electric utilities, underwriters, investors, and rating agencies to better evaluate, quantify, and disclose water risks in utility bonds.

Assessing Water Risk: A Model

This report includes an innovative quantitative model, developed by PwC, to assess both water and electric utility water risk exposure by comparing their available supplies with projected water demand from 2011 to 2030. Drawing on public information gathered from federal reports, bond statements, and utility planning documents, the model generates a set of water risk scores that can be used by investors and credit rating agencies to better understand relative water risks among utility bonds. By coupling the water risk scores with other financial information already available in credit rating opinions and bond documents, investors can gain a more complete picture of a bond's total risk profile.

The water risk scores were designed to give a sense of the relative risk of undersupply of water over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk score is **not** an indicator of the likelihood of default.

The model was applied to eight investment-grade public utility bonds: six water bonds and two electric power bonds. The 30-year bonds are all in regions with growing populations and increasing pressures on water supplies. Other public utility bonds not modeled in this study may also face water risks.

To quantitatively assess a utility's exposure to water undersupply, the model simulates the projected levels of monthly water flows from water sources used by the utility and compares the available water to the utility's monthly demand. Climate change presents many possible future scenarios with varying impacts. The simulations are conducted under four different climate change scenarios with varying expectations of wet and dry weather, and with various stress scenarios that would constrict water supplies for one- to five-year time frames.

The stress scenarios reflect risks such as prolonged drought, interstate or regional legal conflicts over water supplies, and regulatory actions aimed at protecting endangered species and preserving water flows. Many of these scenarios are not unexpected for these eight utilities, which are already aware of such threats. Yet, their current bond ratings do not reflect such risks—let alone encourage them to take the appropriate steps to reduce the risks.

The model draws on a resource planning software tool created in cooperation with water utilities, the Water Evaluation and Assessment Project (WEAP), to evaluate physical water flows, which were then combined with the shorter-term stress scenarios to produce specific water risk scores. The stress scenarios for water utilities range from a 10 percent supply reduction, to a more extreme scenario of a 30 percent supply reduction for three years at the utility's most significant water source coupled with a 50 percent capacity reduction in storage for five years. For electric utilities, stress scenarios test the utility's sensitivity to supply stresses, including a 30 percent reduction in available water for three years, and demand stresses that test the potential for major facilities to expand generation capacity to fuel growing electricity demand.

Findings

The six water utility bonds that were modeled received wide-ranging water risk scores.

Among the key findings for the six water utility bonds (see **Chapter Four** for details):

- The **Los Angeles** Department of Water & Power's water system bond received the highest risk score of all water utilities, based on tight restrictions on local water supplies due to environmental regulations and prolonged drought. The municipal system, the nation's largest, is also highly reliant on vulnerable water imports, including the Colorado River. The utility's water bond was rated "AA+" and "Aa2" by Fitch and Moody's, respectively, earlier this year.
- **Atlanta's** Water and Sewer System received the second highest water risk score, a direct result of its reliance on one key local water supply whose future is jeopardized by a judicial order that may require the city to reduce its withdrawals by as much as 40 percent in 2012. The utility's water bond received "A" and "A1" ratings from Fitch and Moody's, respectively, earlier this year.
- The **Phoenix and Glendale, AZ** utilities—systems with high reliance on increasingly expensive and potentially volatile out-of-state water imports from the Colorado River—also received high water risks scores. The Phoenix bond is rated "AAA" and Glendale bond "AA" by Standard & Poor's.
- Water risk scores for the **Tarrant County, TX** utility were double those of the neighboring **Dallas** system. The wide gap is the result of Tarrant County's consistent drawdown on critical storage reservoirs to meet water demand, which makes the system more vulnerable to prolonged drought. Both utilities have identical credit ratings.

Based on other financial factors, the six water utilities profiled have far different capacities to manage their respective water risks, whether by borrowing more money to develop new water supplies or managing demand through more aggressive water pricing and conservation programs. A utility with high water risk scores and low debt capacity will likely have more difficulty managing water risk than a utility with similar risk scores and a higher ratio of revenue to debt service costs. Similarly, a utility with high water risk scores and relatively low water rates may be better positioned to reduce its water risks by managing demand, compared to a utility with similar risk scores but already higher water rates.

Among the key findings for the two electric utility bonds:

- **Alabama's PowerSouth Energy Cooperative,** which provides power to 49 counties in rural Alabama and northwestern Florida, received the higher risk score, primarily due to the system's potential vulnerability to increased water temperatures and lower flows in the Tombigbee River, the cooling water source for its largest coal-fired plant. The utility's bond received "A-" ratings with stable outlooks from both Fitch and S&P last year.
- The **Los Angeles** electric power system's risks are driven in part by reductions in power generated at the Hoover Dam due to low water flows in the Colorado River Basin. The system may also see reduced power deliveries from one of its major coal-fired power plants in Utah, due to heavy competition for dwindling cooling water flows. The utility's bond received "AA" and "Aa3" ratings this year from Fitch and Moody's.

Investor Risks and the Role of Credit Rating Agencies

Reduced revenues caused by water supply shortfalls can compromise the value of utility bonds in two ways. First, reduced revenues can undercut a utility's ability to make timely payments to bond holders, potentially leading to default. Second, diminished credit capacity of a utility may result in a negative outlook or financial stress that may reduce the price of the bonds when sold on the secondary market.

Utilities that fail to factor water stress into water or power pricing, debt reserves and capital expenditures may find themselves in a vicious cycle of credit stress as they face constraints on water supply, are unable to make key system investments to deliver services, and are increasingly reliant on tenuous pricing adjustments and tax referenda to maintain their financial position.

Yet bond investors are largely unaware of these risks—and the uneven scrutiny of the credit rating agencies in evaluating these risks is a big reason why.

Our analysis shows that credit ratings agencies' methodologies largely ignore water risk and may even unintentionally foster wasteful water consumption. Many credit ratings reward pricing and infrastructure plans that encourage increased water use and revenue growth with disregard for even near-term supply constraints and likely disruptions.

No current ratings methodologies reward water utilities for having water pricing that reflects scarcity and encourages conservation or for selecting supply alternatives that boost local resources in favor of risky water imports. Moreover, the ratings agencies routinely assume water supplies will be consistent with the recent past, and do not conduct "stress tests" on utility systems to understand the revenue effects of supply shocks.

Ratings agencies also fall short in scrutinizing water risks to electric power utilities. Many of these utilities are dependent on water supplies for cooling and are vulnerable to generation shutdowns if supplies are disrupted. Yet credit agencies focus little or no attention on the financial impacts of such risks.

Key Recommendations

Investors, rating agencies, and public utilities all need to do a better job of managing their exposure to water scarcity risks. Screening out utility bonds based on geography alone may be insufficient to shield a portfolio from water risks since it would have the effect of limiting investment in utilities with sound management practices. Improved information and disclosure of issuers' exposure and sensitivity to water stress is critical on all fronts. Such disclosure will protect investors from such risks and drive improved management of ever-scarcer water resources.

Below is a summary of key recommendations for utilities, investors, and credit rating agencies to manage emerging water risks in utility bonds (detailed recommendations are in **Chapter Five**).

Water Utilities

- **Improve disclosure of material water stresses** such as exposure to persistent drought or long-term climatic changes, interstate legal conflicts over shared water resources, and potential and existing regulatory actions related to environmental flows. Disclosure should also include an assessment of potential capital costs, rate adjustments, and revenue effects from water supply risks.
- **Implement strategies to manage demand and reduce leakage,** such as cost-effective infrastructure improvements to reduce water loss, and deployment of conservation incentives and new pricing strategies that reflect water scarcity and reward water-savings.
- **Invest in infrastructure that reduces risk** such as "closed loop" alternative supplies (including indirect potable reuse), and green infrastructure that restores natural hydrological systems, promotes rainwater harvesting and natural water capture, thus recharging aquifers and protecting water supplies.

Electric Utilities

- **Improve disclosure of material water stresses** caused by increased competition for water, emerging regulations, and changing climatic conditions. Such disclosure should also include information on key water sources, the water intensity of generation, as well as potential capital costs, rate adjustments, and revenue impacts from water risks.
- **Invest in measures to reduce risk**, such as strategies for reducing energy use and therefore water demand. These measures include investments in energy efficiency programs, rebalancing generation portfolios toward low-water intensity, clean energy, and investing in cost-effective alternative water supplies, including reclaimed water.

Bond Underwriters

- **Assist utilities in disclosing their sensitivity to water stress and plans for mitigating their risk.** To fulfill their duty to assist issuers in disclosing all material risks in official statements and reports, underwriters should ensure that issuers adequately disclose material water risks and water-related events—including legal rulings and regulatory actions—that may materially impair a utility's revenue stream or impose significant capital costs.
- **Help to secure competitive cost of capital for utilities managing water risk.** Underwriters should help issuers that are undertaking strategies to reduce water risk—such as pursuing demand-side management or investing in more secure alternative supplies—to secure lower cost of capital.

Rating Agencies

- **Employ water risk stress tests** to understand an issuer's sensitivity to stresses such as legal rulings over contested resources, restrictions for environmental reasons, or changing climatic conditions.
- **Factor water intensity into rating opinions for electric utilities.** Rating agencies can help investors understand this water risk by incorporating factors such as utilities' water intensity, incidence of water-related shutdowns, and vulnerability of cooling systems to physical and regulatory risks into rating opinions.
- **Reward, via higher ratings, utilities** that manage water demand through pricing in anticipation of future supply constraints.

Investors

- **Engage utilities on their sensitivity to water stress**, principally by encouraging better disclosure of water risks.
- **Encourage asset managers, who oversee their investments, to assess and engage utilities on water risks.** Investors can ask for this via asset manager requests for proposals and annual performance reviews.
- **Request guidance from financial regulators for better disclosure of water and climate-related risks by municipal utilities.** Municipal issuers are not subject to the Securities and Exchange Commission's (SEC) 2010 interpretive guidance, which directs corporate issuers to disclose material information related to the physical effects of climate change, including water risks. To ensure similar disclosure by municipal utilities, investors should engage the Municipal Securities Rulemaking Board and the SEC to provide guidance to issuers and underwriters regarding disclosure of material water and climate risks.

Overview

Water projects helped transform the United States into the most productive economy in history. The delivery of water from ancient aquifers and highland snowpack has enabled agriculture and industry to take root on some of the most parched lands in the northern hemisphere.

The very act of channeling water has generated economic value and forestalled economic crisis. It was the deep waters of the Ogallala Aquifer that tamped the choking dirt storms of the 1930s Dust Bowl and revitalized vast regions of grain production in the American heartland. It was the damming of the Colorado River and countless other waterways that employed tides of workers and powered the American West.

Water has historically fueled our economic development, but today the limits of our water supplies are being tested—threatening to restrict economic development and even the reliability of economic linchpins such as electric power. More extreme droughts, surging water demand and water pollution are idling once-productive farms and spurring litigation between states battling for supplies. Reduced water supply means more threats to endangered species and critical ecosystems, resulting in stronger environmental regulations that also restrict water access, creating the basis for further legal battles.

These trends present real risks for investors who supply the vast amount of capital needed to build and maintain the nation's water and power infrastructure. This report will demonstrate why investors should treat water as a growing credit risk factor for both public water and electric power utilities, and suggest how investors can improve water risk disclosure and analysis within the public utility debt market.

*In this report, **public utilities** are defined as electric power or water systems governed by municipalities, counties or regional governments. These systems are self-financed through sale revenues and occasionally through tax revenues and other transfer payments.*

Public utilities are distinct from investor-owned utilities (IOUs), which may be privately owned or publicly traded on exchanges.

Public Utilities, Investors and Municipal Bond Markets

In the United States, it is largely public utilities that supply water and electricity—fundamental cogs of economic activity—to households and Fortune 500 businesses alike. An estimated 258 million Americans—more than 80 percent of the population—rely on public water supplies.[1] Some 90 percent of that supply is delivered by more than 53,000 state and municipal water utilities.[2] Public power utilities occupy a smaller but still significant proportion of the nation's electric grid, delivering electricity to over 45 million people in the United States, ranging from the most rural areas to some of the nation's largest cities, including Los Angeles, San Antonio, Seattle, and Orlando.[3]

1 J.F. Kenny et al., "USGS Circular 1344: Estimated use of water in the United States in 2005," U.S. Geological Survey, 2009.

2 "2009 Drinking Water Report Card," American Society of Civil Engineers, http://www.infrastructurereportcard.org/fact-sheet/drinking-water#conditions

3 "About Public Power," American Public Power Association, http://www.appanet.org/aboutpublic/index.cfm?ItemNumber=429&navItemNumber=20955

Water and power utilities require reliable supplies of water to generate revenue to repay debt, invest in infrastructure and satisfy their investors.

In 2009, public utilities made up about 10 percent of the nearly $3 trillion municipal bond market in daily trading volume.

Both water and power utilities require reliable supplies of water to generate revenue to repay debt, invest in infrastructure, and satisfy their bond holders. Water utilities generate revenue through the treatment and delivery of water to their commercial and residential customers. Depending on their generation portfolio, electric power utilities may use water for hydropower production or to cool equipment and manage emissions from their generating facilities. Power production is enormously water-intensive. A single nuclear generating unit can use as much as 1.1 million gallons of water *per minute.*[4]

Investors help public utilities deliver these services by supplying capital for system maintenance and expansion. Because of the capital-intensive nature of their services, public utilities issue large amounts of debt. In 2009, public utilities made up about 10 percent of the nearly $3 trillion municipal bond market in daily trading volume.[5] For the most part, public utilities rely on sales revenue to repay debt. Very few public utility bonds pledge tax revenues or other municipal sources of income.

Growing Financial Risks from Threatened Water Supplies

Public utilities are at the frontline of a perfect storm of financial risks from growing water and power demand, increasing water supply pressures, and a tightening regulatory environment. How water and electric utilities manage these risks—which are further compounded by an aging and increasingly impaired infrastructure—will shape their ability to service customers, collect revenue, and maintain competitive credit positions.

Over the next decade, public utilities will need to issue billions of dollars of debt to replace aging infrastructure and expand service to growing populations. Much of that debt is necessary simply to upgrade existing systems from their near-failing grades—the American Society of Civil Engineers (ASCE) has given the average drinking water and wastewater system a D-, citing a $100 billion shortfall for routine maintenance for the next five years alone (see **Exhibit 1**).[6] A 2007 EPA estimate found that drinking water utilities face a total financing gap of $334.8 billion over a 20-year period.[7] Electric utilities fare little better. According to ASCE, America's electric power providers face a $45 billion five-year shortfall simply to finance basic infrastructure maintenance needed to improve the average system from its current D+ grade.[8] Billions more will be required for utilities to adapt to the changing and growing stresses on water supplies.

Today, most public utility disclosures and credit ratings apply the faulty assumption that future water availability will resemble the past. Investors helping utilities to finance capital improvements may be exposed to water risks obscured by credit ratings and utility disclosures that devote inadequate attention to these issues.

An example of this is a 2009 opinion by Moody's Investor Services affirming the Atlanta water system's stable credit rating for $3.24 billion in debt, predicated in part on the sufficiency of Atlanta's water supplies in the coming years. Yet, due to protracted water supply constraints in the southeast United States, a judicial order may reduce by as much as 40 percent Atlanta's water withdrawals as early as 2012.

4 "U.S. Utilities: California, New York Move to Require Cooling Towers, Raising Risks to Nuclear Generators," Bernstein Research, May 10, 2010.

5 "2009 Fact Book," Municipal Securities Rulemaking Board, April 2010.

6 "Report Card for America's Infrastructure," American Society of Civil Engineers, 2009, http://www.infrastructurereportcard.org/

7 United States Environmental Protection Agency, "2009 Drinking Water Infrastructure Needs Survey and Assessment" *Fourth Report to Congress EPA 816-R-09-001,* 2009, http://water.epa.gov/infrastructure/drinkingwater/dwns/upload/2009_03_26_needssurvey_2007_report_needssurvey_2007.pdf

8 American Society of Civil Engineers, 2009.

Exhibit 1: America's Aging Water Infrastructure

Chronic underinvestment in U.S. water infrastructure has a heavy toll:

- Many water utilities suffer considerable water losses from aging and poorly maintained pipes. The national average for water losses in major U.S. cities is between 10-15 percent of treated supply, with some older cities such as Detroit, Pittsburgh, and Philadelphia reaching loss levels of up to 25-30 percent each year.
- More than 18 billion gallons per day of water are lost to leakage, poor accounting and other unbilled consumption. These losses are estimated at an annual cost of $2.6 billion.
- According to the EPA, each year there are 240,000 water main breaks, with this number expected to rise as U.S. water systems age. Over a 19-year period, large utility breaks in the Midwest increased nearly ten-fold, from 250 per year to 2,200 per year. On average, the replacement cost value of water mains is about $6,300 per household in 2007 dollars for large utilities with the greatest economy of scale.

Source: U.S. Environmental Protection Agency, Aging Water Infrastructure Program, "Addressing the challenge through innovation," 2007, www.epa.gov/nrmrl/pubs/600f07015/600f07015.pdf

Today, most public utility disclosures and credit ratings apply the faulty assumption that future water availability will resemble the past.

In the public power sector, rating agencies completely neglect water-related shutdowns at coal and nuclear power plants, despite their growing frequencies. Nor do rating opinions factor in emerging water-related regulations with the potential to necessitate capital expenditures from several hundred million to several billion dollars at a single generating facility, even though such regulations are likely to affect facilities providing nearly half the electric power generation capacity of the United States.[9]

While all of these emerging water risks can damage the value of investors' public utility assets, many remain invisible. Increased resource competition, more intense droughts, and regulations to ensure reliable water supplies are all likely to translate into additional capital expenditures and increased operating costs for already highly-leveraged utilities. In the most extreme cases, emerging water risks may force capital assets into early retirement or saddle utilities with stranded assets. Any of these scenarios may impair a utility's liquidity, undermining its ability to honor debt obligations to investors. Yet today's utility disclosure and credit analysis fails to incorporate these trends, placing investors at risk.

9 Bernstein Research, 2010.

WATER IN SHORT SUPPLY

Populations and economic activity are growing rapidly in areas with significant water stress, including the coastal West, Southwest and Southeast.

*In this report, **water stress** describes a situation in which regional demand for water exceeds the local supply of water suitable for the intended use.*

Escalating Water Pressures

Growth in both populations and water use in the country's most arid regions, climate change, increased incidence of interstate legal action over water supplies, and the massive water demands of the U.S. electric power system are escalating pressures on water resources.

POPULATION GROWTH IN ARID REGIONS

While the United States has ample water supplies when viewed in total, populations and economic activity are growing rapidly in areas with significant water stress. This mismatch between regional demand and supply will increasingly pose challenges to economic productivity—and to public water and power utilities and their investors. Because water is costly to transport, better water planning to manage demand and augment supplies will determine which regions remain most competitive. In turn, the success or failure of regions to manage this crucial economic input will shape growth rates and overall economic performance.

Despite a nearly 30 percent increase in population, total U.S. water consumption has remained relatively flat over the past 20 years, thanks to improved water efficiency. Demand from the most water-intensive industry sectors, including agriculture and electric power generation, has even declined overall.[10]

Yet this picture conceals the growing water demand in areas of rapid population growth. The coastal West, Southwest, and Southeast have seen some of the highest growth rates in water consumption over the past decade as populations and high-growth industries have moved to warmer "Sunbelt" regions.

Per capita water consumption rates in fact tend to be highest in these mostly arid regions due to migration of water-intensive industries, insufficient rainfall for agriculture and landscaping, and higher relative demand for water-intensive leisure activities (see **Table 1**).

10 J.F. Kenny et al., 2009.

Table 1: Population Growth, Precipitation and Water Use in 10 U.S. Cities

City	Population Growth Since 2000[a]	Average Annual Precipitation (cm)[b]	Average Per Capita Daily Residential Water Use (gal)[b]
Los Angeles	125,131	30	n/a
New York	77,464	120	78
Phoenix	67,371	19	115
Houston	56,059	117	72
Fort Worth	50,428	86	81
San Diego	43,353	25	105
Las Vegas	38,583	10	110
Tucson	20,959	30	98
Dallas	19,738	86	57
Atlanta	6,545	129	106[c]

a “The fastest growing US cities,” City Mayors, http://www.citymayors.com/gratis/uscities_growth.html

b Unless otherwise noted: “The Price of Water: A Comparison of Water Rates, Usage in 30 U.S. Cities,” Circle of Blue, April 26, 2010.

c Data is for all of Fulton County. Metropolitan North Georgia Water Planning District, Water Supply and Water Conservation Management Plan, May 2009.

Without meaningful planning and investments in conservation, by 2030, increasing population growth and higher per capita water use in these areas is projected to account for as much as a 48 percent increase in U.S. water use from 2005 levels.[11, 12] Conversely, areas such as the Northeast and Great Lakes with sufficient local precipitation to support agriculture, commercial and personal use are experiencing stable or even declining populations.

STATES BATTLING FOR SUPPLIES

As demand for water in arid and semi-arid regions grows, interstate water conflicts are multiplying (see Exhibit 2). Despite efforts by the federal courts, the Department of the Interior, the U.S. Army Corps of Engineers and Presidential administrations to resolve water conflicts, water supplies of some of the most populous and economically productive areas of the country remain contested and potentially over-allocated:

- **The Colorado River Basin:** The 242,900-square-mile basin extending from Colorado to Mexico is a critical resource for seven states, including Arizona, California, Colorado, and Nevada. Although the 1922 compact assigning water rights assumed an average flow of 16.4 million acre-feet a year, recent studies suggest that the true average may be as much as three million acre-feet less. Fast-growing populations relying on the river’s water are already being forced to reduce consumption significantly and to develop alternative supplies that also may not be reliable, posing risks to investors whose bond purchases finance these projects.
- **Apalachicola-Chattahoochee-Flint (ACF) River Basin:** For almost two decades, Alabama, Florida, and Georgia have been locked in a legal battle over the waters of the ACF Basin. The focus of the dispute is Lake Lanier, a project of the U.S. Army Corps of Engineers, which since 1960 has allowed Atlanta to use the lake to supply drinking water to its growing population. The lake now supplies nearly 75 percent of the metropolitan region’s water. In 2007, the city was forced to surrender 22 billion gallons of water from the lake to support threatened species in Florida’s Apalachicola Bay. The order coincided with a drought, touching off a legal battle and water

11 National Energy Technology Laboratory, “Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements,” September 30, 2008. This report describes potential daily water consumption as increasing from 3.7 billion gallons per day in 2005 to between 4.7 and 5.5 billion gallons per day in 2030.

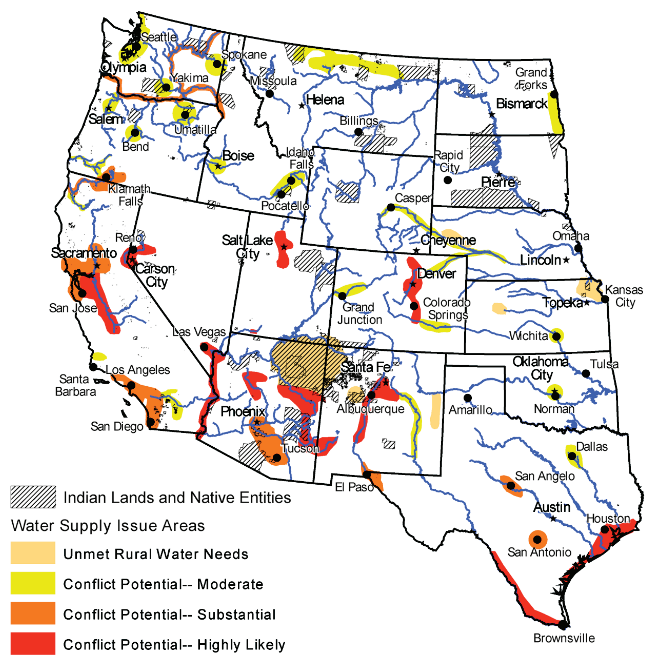
12 Ibid.

restrictions across the metropolitan region.[13] A federal judge has ordered the states to reach agreement over this shared resource by 2012. If no agreement is reached, the city of Atlanta will lose rights to about 40 percent of the water it pulls from Lake Lanier. Without an alternative supply or transformative efficiency improvements, that measure could cost Georgia businesses tens of billions of dollars a year.[14]

- **Red River Basin:** The Red River divides Oklahoma from north Texas, home to the fast-growing Dallas-Fort Worth metropolitan region. With current water use outstripping the reliable supply of local reservoirs, Texas water utilities are looking north of the border to purchase supplies from the potable tributaries of the Red River. Oklahoma legislators, concerned about their own state's growth prospects, have responded by adopting a moratorium on interstate water sales. Tarrant Regional Water District, Dallas Water Utilities, and neighboring utilities are contesting the moratorium in the U.S. Court of Appeals.[15] Whatever decision is taken by the court, water transfers must receive the additional support of the Chickasaw and Choctaw Tribal Nations.[16]

If no agreement is reached, the city of Atlanta will lose rights to about 40% of the water it pulls from Lake Lanier ... the measure could imperil the credit of the Atlanta water utility, already struggling with a heavy debt burden.

Exhibit 2: Potential Water Supply Conflicts By 2025



Source: "Global Climate Change Impacts in the United States," U.S. Global Change Research Program, 2009.

13 "Florida, Alabama, Georgia water sharing," WaterWebster, http://www.waterwebster.com/FloridaAlabamaGeorgia.htm

14 "Water Contingency Task Force Presents Final Recommendations," Press Release, State of Georgia Office of the Governor, December 22, 2009.

15 Bill Hanna, "Tarrant County district's bid for Oklahoma water dismissed," *Star-Telegram*, July 16, 2010.

16 "Questions and Answers: State/Tribal Water Compact & Southeast Oklahoma Water Resources Development Plan," Oklahoma Water Resources Board, http://www.owrb.ok.gov/studies/legislative/southeast/southeast_pdf/questions_answers.pdf

WATER DEMANDS FOR ENERGY GENERATION

Energy use in regions with growing populations is also driving up water demand. Electric power plants already account for 41 percent of freshwater withdrawals in the United States.[17] Most of that water is used for cooling power plant equipment. While the majority of that water is withdrawn but not consumed—meaning it is returned to its source—almost all existing power plants in the country require large amounts of water, making them vulnerable to water shortages. Electric generating capacity may increase by nearly 18 percent between 2005 and 2030[18] (much less if the country makes significant investments in energy efficiency), making the water intensity of electric power production a primary concern for new and existing facilities.

Electric power plants already account for 41 percent of freshwater withdrawals in the United States.

Without meaningful conservation measures, national water consumption is expected to grow from 3.7 billion gallons per day in 2005 to between 4.7 and 5.5 billion gallons per day by 2030. If realized, such extraordinary growth in economy-wide water consumption will put pressures on the water withdrawal and consumption prospects for electric power, especially in the West, Southwest, and Southeast.[19]

New efforts to reduce greenhouse gas emissions from power plants may also increase pressure on water supplies. Carbon capture and storage (CCS), which may be needed to control carbon emissions from coal-fired power plants, increases overall cooling requirements and therefore requires a significant increase in water use. A Department of Energy study estimated that by 2030, CCS deployment could increase the water consumption of a coal-fired power plant by an average of 103 percent.[20]

ENERGY DEMANDS OF WATER DELIVERY

Water delivery is hugely energy-intensive, with about three percent of national energy consumption used for water and wastewater services.[21] Water delivery entails water conveyance from source to user, treatment of water (often to potable standards regardless of future use), and treatment of wastewater for ultimate release. Energy demand for drinking water and wastewater treatment will likely increase as pollutant concentrations rise from human activities and as water quality regulations tighten.

Transporting water from water-rich to water-poor regions is an energy-intensive practice fueling regional growth across the southern and western United States. The California Aqueduct, which transports snowmelt across two mountain ranges to two-dozen coastal cities, is the biggest electricity consumer in the state.[22] The California Energy Commission found that water conveyance, storage, treatment, distribution, and wastewater collection consumed about 19 percent of the state's electricity in 2001.[23] The Central Arizona Project, a 336-mile canal that pumps Colorado River water 3,000 feet in elevation to Arizona's largest cities, draws 2.8 million megawatt hours a year, making it the biggest electricity user in the state.[24, 25] As a result, each acre-foot of water delivered comes with a steep energy cost—more than 1,500 kWh of electricity for Phoenix and 3,200 kWh for Tucson.[26]

17 J.F. Kenny et al., 2009.
18 National Energy Technology Laboratory, 2008.
19 Ibid.
20 Ibid.
21 United States Environmental Protection Agency, "Sustainable Infrastructure for Water & Wastewater," last updated August 18, 2009, http:// www.epa.gov/waterinfrastructure/bettermanagement_energy.html
22 Ronnie Cohen, Barry Nelson and Gary Wolff, "Energy Down the Drain: The Hidden Costs of California's Water Supply," Natural Resources Defense Council and Pacific Institute, Oakland, California, August 2004.
23 "California's Water-Energy Relationship," California Energy Commission, 2005.
24 Shaun McKinnon. "Arizona's water and power supplies intertwined," The Arizona Republic, December 7, 2008, http://www.azcentral.com/arizonarepublic/news/articles/2008/12/07/20081207sustain-watergy1207.html?&wired
25 Central Arizona Project Navajo Generating Station, http://www.cap-az.com/public-information/ngs/
26 Environmental Defense Fund and Western Resource Advocates, "Protecting the Lifeline of the West: How Climate and Clean Energy Policies Can Safeguard Water," 2010.

Across the interior West, cities with burgeoning populations and water demands are proposing far-reaching water conveyance systems that are likely to be bond financed.

Across the interior West, cities with burgeoning populations and water demands are proposing far-reaching water conveyance systems. These capital-intensive projects are likely to be bond financed.

- The Southern Nevada Water Authority is proposing to build a nearly 300-mile pipeline to deliver 11 billion gallons of water each year from rural northeastern Nevada. The $3.5 billion project is intended to supplement dwindling Lake Mead supplies. The water authority has already invested $700 million to build a "third straw" to draw shrinking water supplies from the drought-stricken lake.[27]
- Three southern Utah counties are seeking to develop a 160-mile pipeline transporting 325 billion gallons of water per year from Arizona's Lake Powell. The project has an estimated energy requirement of 4.5 million MWh per year.[28]
- In Colorado, the proposed Regional Water Supply Project (RWSP) would move 225,000 acre-feet of water up to 500 miles—from Flaming Gorge Reservoir to the Front Range of Colorado. The RWSP would lift water over the Continental Divide, and if powered by electricity, have greenhouse gas emissions equivalent to burning 48 million gallons of gasoline each year.[29]

Beyond high upfront construction costs that will bring heavy debt burdens, these energy-intensive conveyance systems may have significant operating costs through their exposure to volatile energy prices. The compounded effects of high construction and operating costs may reduce issuer liquidity, straining utility capacity to honor existing and future debt obligations.

Emerging Risk Factors for Water Supplies

As rising regional demand for water collides with more volatile supplies, utility balance sheets will feel the pinch. In many parts of the United States, utilities are facing water supply constrictions that create revenue challenges for water and electric utilities. Emerging risks fall into two basic categories:

- **Physical factors**, including *quantity* reductions due to drought or drawdown by other users and *quality* impairments from pollution or intrusion of salt water driven by excessive groundwater pumping, land subsidence, and sea level rise, and
- **Regulatory factors**, including changing allocations of water rights among users, preservation of environmental flows to protect endangered or threatened species, or quality standards that impose additional costs or limit use of a water resource.

Climate change is expected to exacerbate both physical extremes and regulatory responses intended to protect water supplies for human uses and threatened species.

RISK FACTOR: DROUGHT

Because precipitation in the form of rain or snowfall is the predominant source of freshwater supply for much of the United States, drought is one of the most significant supply threats to public utilities.

27 Henry Brean, "'Third-Straw': Water authority digs deep for third intake pipe at Lake Mead," *Las Vegas Review-Journal*, December 13, 2009.

28 Stacy Tellinghuisen, Western Resource Advocates, "Pipelines and Power Plants: The Energy Needs of the West's Future Water Supplies," (presentation, U.S. Environmental Protection Agency, July 2010).

29 Ibid.

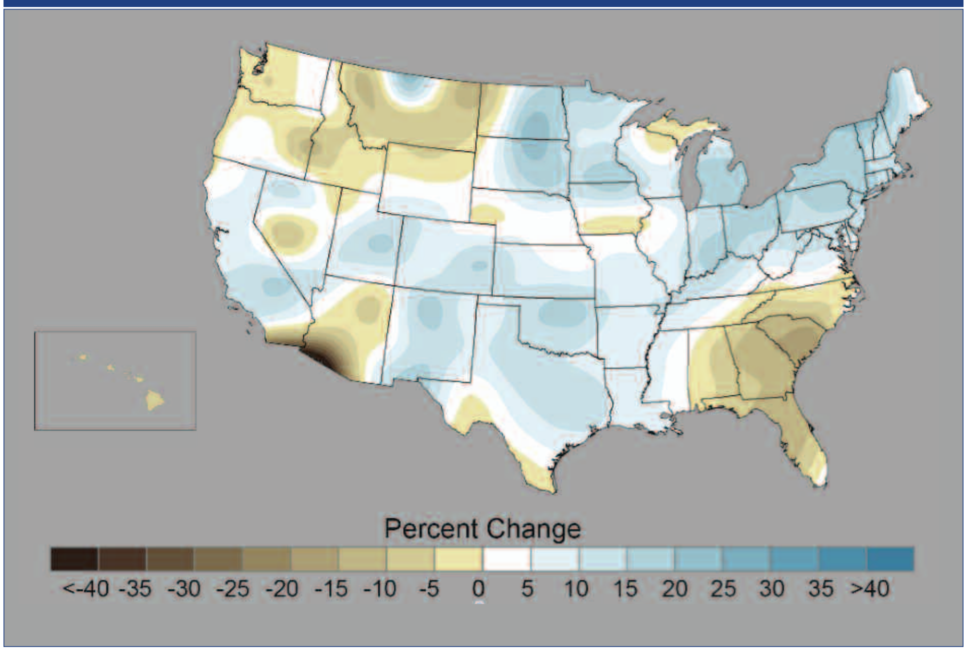
Water In Short Supply

For the most part, utilities manage water based on observations of the recent past, typically the past 50-100 years. Water rights and infrastructure have been designed to manage water use in a normal year against the near-term historic average flow, and in times of shortage, against the worst drought of near-term historic record. In many constructed water systems, the drought of record is defined as the worst drought since the construction of the system.

Using benchmarks from the recent past may unwittingly expose utilities to significant risk for events that deviate from recent experience. In some areas, utilities may need to recalibrate their definition of averages and extremes, as they look deeper into the scientific record to reveal how hydrological flows have varied over thousands of years. For example, a growing number of hydrologists believe that the present "drought" in the American West may simply be a return to the long-term average, before the unusually wet period of the early 20th century.

A growing number of hydrologists believe that the present "drought" in the American West may simply be a return to the long-term average, before the unusually wet period of the early 20th century.

Exhibit 3: Observed Change in Average Annual Precipitation 1985-2008



Source: "Global Climate Change Impacts in the United States," U.S. Global Change Research Program, 2009.

Exhibit 4:
Atanta's 2007-2008 Drought

While Atlanta's 2007-2008 drought was orders of magnitude less severe than those experienced in the West, its vulnerable drinking water infrastructure brought the city close to undersupply. Lake Lanier provides around 75 percent of the city's water. At the height of the drought, the lake's water level fell within three months of dead pool, the level at which water no longer flows over the dam. Had the level dropped to the dead pool height, the city would have been cut off from its primary source of water.

Source: CNN Sunday Morning, Transcript of interview with Governor Sonny Perdue, October 21, 2007.

Drought risk management and infrastructure capacity

Drought is not just a western problem. While areas west of the Mississippi are more prone to extended droughts than the eastern United States, droughts are intensifying in the Southeast (see **Exhibit 3**). Additionally, regions that infrequently experience drought may be more vulnerable than arid regions if they do not have the institutional capacity or infrastructure to manage this stress (**Exhibit 4**).

On both sides of the Mississippi, planning for times of shortage remains an underdeveloped practice. None of the nation's interstate water compacts or watershed commissions have established which priority uses should be maintained during times of drought, according to the National Energy Technology Laboratory.[30]

30 National Energy Technology Laboratory, 2008.

Depending on how water rights are assigned among states, cities and users, two utilities drawing from the same supply may experience very different shortages during a drought. In the western states, water users with prior historical use hold senior claims to water during times of drought. In eastern states, all landowners have equal claim to adjacent water sources, meaning all must reduce their use during times of stress. For public utilities without well established water rights, prolonged stresses on shared water resources are likely to be resolved through judicial action, a protracted and costly process that may not ensure reliable supply during times of extreme stress.

Today, chronic drought in the Colorado River Basin is leading to predictions that Hoover Dam, which provides electricity to major urban centers in California, Arizona, and Nevada, could stop generating electricity as soon as 2013 if water levels in Lake Mead don't start to recover.

Costs of drought

Unreliable water flows can drive price volatility of electric power by temporarily taking cheap hydropower generation off the market—contributing to higher generation costs for utilities and higher electricity costs for consumers. In the late 1990s and early 2000s, low flows in the Pacific Northwest curtailed power production, contributing to price volatility in western electricity markets.[31]

More recently, during the 2007-2008 drought in Georgia, a subsidiary of electric power firm Southern Company was forced to buy $33 million in fossil fuels to replace lost power in Atlanta when hydropower generation declined by half due to low water levels, even though hydropower accounts for only two percent of the utility's generation portfolio.[32]

Today, chronic drought in the Colorado River Basin is leading to predictions that Hoover Dam, which provides electricity to major urban centers in California, Arizona, and Nevada, could stop generating electricity as soon as 2013 if water levels in the lake that feeds the dam don't start to recover.[33]

Persistent reductions in water flows may render infrastructure obsolete and demand unanticipated capital costs. Water intake structures for drinking water supplies and thermoelectric cooling are at a fixed depth. If water levels fall below the intake structure, flowing water may be just out of reach. Rebuilding water intake structures to withdraw water at lower flows can be enormously expensive. Las Vegas is building a lower intake structure to withdraw drinking water from Lake Mead at a cost of $700 million.[34] Because lake bottoms often have greater amounts of sedimentation and debris than upper layers, the city is likely to incur ongoing costs for additional drinking water treatment if it is ever forced to use the lowest intake pipe.

For thermoelectric power, reduced water flows may undermine a utility's ability to get the volume of water needed to cool its facilities to meet electric power demand or to maintain base load generation. Lowering a thermoelectric intake structure can cost upwards of $200 million for a single coal or nuclear power plant,[35] and installing a less water-intensive cooling system can cost more than $1 billion[36] (for more on thermoelectric intake structures, see **Appendix A**).

31 Standard & Poor's, "Western U.S. Hydroelectric Production Takes a Dive, and Utilities Adjust," August 5, 2004.
32 Justin Rubner, "Drought hits Hydropower," *Atlanta Business Chronicle*, November 16, 2007, http://atlanta.bizjournals.com/atlanta/stories/2007/11/19/story2.html
33 Eric Wolff, "Hoover Dam could stop generating electricity as soon as 2013, officials fear," *North County Times*, September 11, 2010, http://www.nctimes.com/business/article_b7e44e9e-087d-53b2-9c49-7ea32262c9a9.html
34 Paul Quinian, "Lake Mead level plunges as 11-year drought lingers," *Greenwire*, August 12, 2010.
35 Michael Hightower, interview with author, July 1, 2010.
36 Bernstein Research, 2010.

Impacts of climate change

Climate change is expected to deepen the intensity and duration of water shortages in arid and semi-arid regions. In the West especially, the effects of more frequent and intense droughts are likely to be compounded by a reduction in the storage provided by snowpack. Higher temperatures mean that even when western regions receive precipitation, it may be more likely to occur as rainfall than snowfall. Western water infrastructure has been designed over the past century to take advantage of the storage provided by snowpack during the winter months. Reductions in snowpack will require water systems to adapt storage infrastructure to replace this formerly free service provided by once-snowy climates.

By mid-century—well within the lifetime of most existing water infrastructure—climate change may cause reliable supplies to fall short of demand in more than one-third of all counties in the continental United States. Arizona, Arkansas, California, Colorado, Florida, Idaho, Kansas, Mississippi, Montana, Nebraska, Nevada, New Mexico, Oklahoma, and Texas are among the states most likely to face extreme water shortages.[37]

Utilities that fail to design and modify their physical systems to account for drought, growing climate variability and risks to their water rights may face unexpected contingency costs and revenue shortages.

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RISK FACTOR: WATER CONTAMINATION

Water contaminants can reduce the supply of safe drinking water, limit electric power production, and pose significant costs to water and power utilities alike. Contamination can be an acute event that limits water use for a few days, or a persistent stress presenting ongoing treatment costs to utilities or even cutting off water resources altogether for years.

Surface water contamination from human waste and manmade pollutants is on the rise in the United States. Heavy rains and flooding now regularly overwhelm the combined sewage and stormwater systems of cities across the country, sending untreated sewage directly into waterways that serve as drinking water sources for adjacent systems. Many water utilities in the Pacific Northwest, Midwest, and Northeast are grappling with rising capital costs from repeat combined sewage overflow incidents and stormwater drain flood events triggered by extreme rainfall not expected from past statistics. New York City's system, designed to handle water from a five-year storm, was overwhelmed by three 25-year storms in 2007 alone, sending raw sewage into the city's rivers.[38] New York and other cities experiencing more frequent heavy rainfall from climate change will be more likely to face consent decrees to expand the capacity of wastewater treatment and stormwater storage as a means of reducing contamination in local waterways.

Groundwater contamination due to pollutant seepage also poses a serious risk. Once an aquifer is contaminated, the cost of treating water to potable standards can be so prohibitive as to render the source unusable, forcing utilities to substitute more expensive sources (see **Exhibit 5**).

Exhibit 5: Groundwater Contamination in Los Angeles

In the 1980s, major industrial groundwater contamination caused the city of Los Angeles to abandon 40 percent of its drinking water wells in the San Fernando Basin, eliminating supply for 800,000 people.[39, 40] To substitute that water, the city has had to expand its water purchases from the Metropolitan Water District, which imports water from the Colorado River hundreds of miles through a series of aqueducts, and which faces volatile supply issues of its own.

37 Natural Resources Defense Council, "Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable," July 2010.

38 Ibid.

39 Charles Duhigg. "That Tap Water is Legal but May Be Unhealthy," *New York Times*, December 17, 2009.

40 United States Environmental Protection Agency, "Region 9: Superfund," see http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/db29676ab46e80818825742600743734/5385870e7c6b8d9b88257007005e946d!OpenDocument

Exhibit 6: Saltwater Intrusion Contaminating Supplies

- In South Carolina, the water utility for the tourist resort town of Hilton Head has abandoned eight of the island's 12 supply wells since 1990 due to saltwater intrusion.
- Miami-Dade County projects a capital burden of $1.9 billion over the next 20 years to manage saltwater intrusion into its water supply.[41]

Saltwater intrusion into freshwater sources has been exacerbated by excessive groundwater pumping in coastal communities from Massachusetts to Florida (Exhibit 6). In coastal areas, fresh groundwater supplies are often situated on top of saline ocean water with a brackish layer of freshwater-saltwater mix in between. Each foot of freshwater pumped from that system brings multiple feet of saline water into the aquifer, thereby reducing the relative amount of freshwater. Excessive freshwater pumping can remove the freshwater more quickly than it can be replaced by the natural hydrology, and can even increase the amount of freshwater in the system that mixes with the saline water, reducing potable supply. Rising relative sea level from climate change is expected to worsen potable water loss by increasing saltwater intrusion.

RISK FACTOR: ENVIRONMENTAL NEEDS AND REGULATION

When environmental needs are not accounted for in historical water agreements, or when water use interferes with ecosystem health, utilities may encounter regulatory obstacles to exercising their water rights.

The Endangered Species Act is one of the most prominent federal and state statutes governing water use. Legal actions to protect habitat have resulted in significant reductions in permissible water withdrawals in order to protect environmental flows (see **Exhibit 7**).

Exhibit 7: Water Restrictions to Protect Threatened Species

Probably no state has seen more species-related water restrictions than California, where aggressive water diversion projects from the early to mid-20th century caused significant environmental damage in watersheds across the state. Since the early 1990s, water delivery to cities across southern California has been scaled back in an effort to restore environmental flows for imperiled species—all in all, amounting to several million acre-feet per year that cities were forced to conserve or replace.

Today, water supplies across the state remain restricted to serve environmental needs, leading utilities to increase their reliance on imported supplies. A 2009 biological opinion by the U.S. Fish and Wildlife Service on the condition of the endangered delta smelt population cut delivery by the state's largest water provider, the State Water Project, by 800,000 acre-feet. Near term economic effects from reductions in Bay Delta deliveries average more than $500 million annually, and can exceed $3 billion in a prolonged dry period.[42]

As development and water delivery encroaches on more fragile ecosystems, water utilities across the country may, like California, experience similar reductions in once reliable flows.

As development and water delivery encroaches on more fragile ecosystems, water utilities across the country may, like California, experience similar reductions in once reliable flows.

Air quality regulations can limit the use of water sources when steady water withdrawals dry up lakes. Over decades, the City of Los Angeles has diverted so much water from Mono and Owens Lakes that dust clouds from the dry lakebeds have imperiled regional air quality. Regulatory actions to allow the lakebeds to refill have cut the city off from 500,000 acre-feet of annual supply. The reduction in the city's water supply has been a major contributor to the steadily increasing proportion of water Los Angeles has to import from the Colorado River and the Bay Delta, now subject to its own reductions to protect endangered delta smelt.

41 Michael Miller, "Good and bad news ahead 'On the Waterfront'," *Miami's Community Newspapers*, December 22, 2008.
42 Berkley Economic Consulting, "Economic Impacts of the Wanger Interim Order for the Delta Smelt," December 8, 2008.

Clean Water Act (CWA) regulations to protect aquatic organisms are already posing steep costs to electric utilities. The largest power plants can withdraw a volume of water equivalent to several Olympic-sized pools each second to cool machinery, often trapping aquatic organisms against intake structure screens or drawing them into the cooling system itself. In the Great Lakes alone, power plant cooling systems are estimated to kill 40 million fish each year.[43]

Under the CWA, the EPA now mandates less water-intensive cooling structures for new plants. Similar regulations under state authority are beginning to affect existing plants as well. New York and California have drafted their own regulations to limit the water withdrawal of existing power plants (**Exhibit 8**). Altogether, these emerging regulations have the potential to pose significant compliance costs to electric generating facilities currently supplying 46 percent of power capacity in the United States.[44]

Exhibit 8: Growing Regulations to Protect Aquatic Species

Nuclear and coal plants use vast amounts of water to cool equipment. In the past year, both California and New York—home to eight percent of U.S. power production—have made moves to require steam turbine plants to install less water-intensive cooling systems.[45]

Although New York's regulations have not yet gone into effect, regulators are signaling their intent to enforce water conservation in the energy sector. The state has refused to renew the 40-year operating permit for Indian Point nuclear plant on New York's Hudson River. To secure the permit, regulators want the plant to build cooling towers that could cost as much as $1.1 billion and reduce water intake by 97 percent.[46] The proposed regulations are meant to protect aquatic species, including the endangered shortnose sturgeon, which are regularly drawn into thermoelectric facility cooling structures. The Indian Point plant is estimated to intake nearly a billion organisms a year in its cooling water withdrawals.

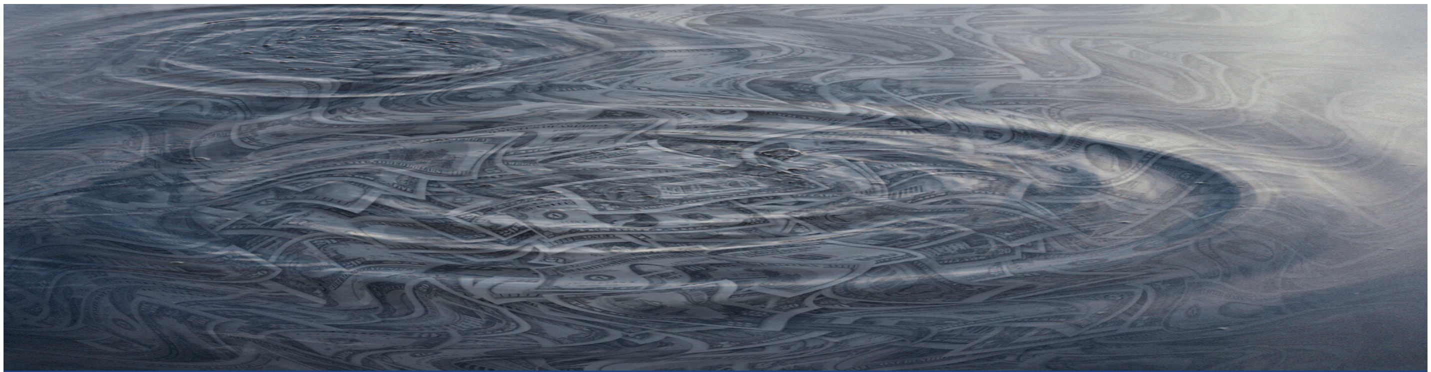
In August 2010, the Tennessee Valley Authority was forced to reduce generation at three of its facilities in Alabama and Tennessee when a heat wave pushed water temperature above permitted levels.

Clean Water Act thermal effluent limits are one of the most immediate and growing water risks to electric generating facilities, as climate change increases ambient water temperatures. In August 2010, the Tennessee Valley Authority (TVA) was forced to reduce generation at three of its facilities in Alabama and Tennessee when a heat wave pushed water temperatures to the permitted maximum temperature of 90°F.[47] One of the affected facilities was Browns Ferry Nuclear Power Plant, which experienced similar generation reductions in August 2007. The two-week incident at Browns Ferry in August 2010 cost TVA an estimated $10 million in lost power production.[48] While regulated thermal effluent limits are nothing new, the higher sustained temperatures and more frequent heat waves already being caused by climate change make it likely that thermoelectric facilities will experience more frequent temperature-related shutdowns.

For more on statutes affecting water availability, see **Appendix B**.

These demand and supply stresses are likely to combine in ways that compound utilities' costs, amplifying investor exposure.

43 Bernstein, 2010.
44 Ibid.
45 Ibid.
46 Matthew Wald, "N.Y. refuses permit to nuclear plant, demands $1.1B cooling towers," *New York Times*, August 23, 2010.
47 Dave Flessner, "TVA cuts plant output," *Chattanooga Times Free Press*, August 3, 2010.
48 Ibid.



WATER RISKS TO PUBLIC UTILITY INVESTORS

Given these pressures, utility bond investors will see financial value in elevating water as a credit risk factor.

The growing gap between reliable regional water supplies and growing demand poses a risk to public utility investments by driving down utility revenues and operating margins, necessitating new capital investments, and heightening the potential for contingency costs.

Independently, many public utilities are expected to increase their debt burden as they make long-delayed investments in basic system upgrades—reducing their financial capacity to adapt to changing water risks.

Given these pressures, utility bond investors will see financial value in elevating water as a credit risk factor. Analyzing such risks will be challenged by generally weak utility disclosure and inconsistent scrutiny by rating agencies of water-related risks. Robust investor interest in this arena will likely accelerate improved water risk disclosure, analysis, and management among public utilities.

Exhibit 1: Regulation of Municipal Security Disclosure

Municipal utilities are exempt from federal securities laws.[49] As such, they are not included in the Securities and Exchange Commission's (SEC) new interpretive guidance for publicly-held companies on disclosure related to the impacts of climate change, including the availability or quality of water.[50]

To improve transparency in the municipal security market, in May 2010 the SEC adopted rule changes to Rule 15c2-12 requiring underwriters and sellers of municipal securities to disclose *important events* within ten business days.

Important events are defined as (1) failure to pay principal and interest; (2) unscheduled payments out of debt service reserves reflecting financial difficulties; (3) unscheduled payments by parties backing the bonds; (4) defeasances, including situations where the issuer has provided for future payment of all obligations under a bond; and (5) rating changes. Underwriters are also required to disclose other events when they qualify as material.

Under current interpretive guidance, it is not clear whether water stress including changes in legal rights to water or judicial rulings limiting water deliveries rise to the level of *material events*.

49 Securities and Exchange Commission, "SEC Approves Rule Changes to Enhance Municipal Securities Disclosure," May 26, 2010, http://www.sec.gov/news/press/2010/2010-85.htm

50 Securities and Exchange Commission, 17 CFR PARTS 211, 231 and 241 [Release Nos. 33-9106; 34-61469; FR-82] *Commission Guidance Regarding Disclosure Related to Climate Change*, February 2, 2010, www.sec.gov/rules/interp/2010/33-9106.pdf

Credit Risks for Public Water Utilities

Though the cost of mitigating growing water risks may be spread over decades, the reality is that many water utilities will need to finance capital improvements to make up for decades of deferred maintenance while addressing some combination of supply and demand stresses. Such stresses are already reducing the financial flexibility of water utilities today, including reduced revenues and slimmer debt coverage ratios.

EXISTING FINANCIAL TRENDS LIMIT UTILITIES' ABILITY TO MANAGE WATER RISK

Despite these mounting risks, debt issued by water utilities traditionally has been considered a relatively safe investment. There are three key reasons for this:

- Water utilities provide an essential service. Water is a non-substitutable good used by everyone.
- Water utilities enjoy a near monopoly—more than 80 percent of the U.S. population relies on them for clean drinking water, and within service areas there is virtually no competition.
- Municipal utilities have some degree of flexibility in setting rates, which offers some security that costs will be recovered and revenue projections attained.[51]

These conditions have supported historically minimal default rates within the sector. Among the three biggest credit agencies—Standard & Poor's, Moody's, and Fitch—public water utilities receive an average rating of investment grade quality. [52]

Yet while these conditions are generally true, politics, poor disclosure, and regressive credit analysis can discourage utilities from managing growing water stress, with material implications for investors.

The following sector-wide trends highlight the widening gap between the resources required to sustain revenue-generating growth and utilities' growing debt burdens—gaps that may compromise the financial flexibility of utilities and the long-term value and performance of water utility bonds:

Public utility debt burdens are expected to increase.

- Aging infrastructure, including leaking pipes, dams, drainage and treatment facilities, are past due for replacement.
- Large water systems are expected to see a 40 percent increase in long-term debt in the next five years; mid-size systems around 50 percent, mainly to finance asset replacement and system expansion from service territory growth.[53] Anticipated debt increases do not include projections for securing additional supplies or other steps to manage increasingly volatile supplies. This rising debt reduces the capacity of utilities to take on future leverage to address water supply constraints.[54]

Large water systems are expected to see a 40 percent increase in long-term debt in the next five years.

51 "Water and Sewer Revenue Bond Rating Guidelines," Fitch Ratings, August 6, 2008.
52 See Fitch 2008 and "Analytical Framework for Water and Sewer System Ratings," and Moody's Investors Service, August 1999.
53 Fitch Ratings, "2010 Water and Sewer Sector Retail Medians and Outlook," April 8, 2010.
54 Ibid.

Regions with the most serious water availability challenges have the lowest rates for water and sewage services in the country.

Table 1: Typical Monthly Water Bills in 15 U.S. Cities	
Residential Customers, 3,750 Gallons Billable Water Usage	
Dallas	$9.53
Las Vegas	$10.81
Denver	$11.57
Austin	$12.74
Tucson	$13.02
Fort Worth	$16.00
San Antonio	$16.36
Albuquerque	$16.48
Los Angeles	$17.11
Phoenix	$17.29
Atlanta	$19.81
Long Beach	$20.27
Baltimore	$24.69
Seattle	$28.48
San Diego	$30.50

Source: Black & Veatch 2009/2010 Water/Wastewater Rate Survey, 2010.

Future debt capacity is expected to erode.

- For many utilities, the ratio of revenues to debt service expenditures, as measured by the Annual Debt Service Coverage Ratio (ADS), is rapidly shrinking. Today, the median ADS for large water systems is around 1.7, with minimum projected all-in ADS expected to fall to 1.5 in the very near term.[55]
- Many utilities are bound by legal covenants requiring a minimum ADS of 1.1-1.3 (meaning that revenues are 110-130 percent of annual principal and interest payments), not far from projected near-term ratios, leaving little room for additional debt financing.

Water rates do not reflect resource scarcity.

- Regions with the most serious water availability challenges have the lowest rates for water and sewer services in the nation (see **Table 1**). For example, a family of four using 100 gallons per person each day will pay on average $32.93 a month in Las Vegas compared to $72.95 for the same amount in Atlanta, which has more than ten times the amount of average annual rainfall as Las Vegas.[56] This trend holds fairly well across regions: typical rates in the coastal West are slightly over one percent of Median Household Income (MHI) and in the Southwest around 1.25 percent of MHI, compared to the national average of 1.5 percent of MHI.[57]
- Utilities seeking to raising water rates to convey the true cost of each additional gallon of water delivered often face considerable political backlash. In a recent example, the mayor of Livingston, California was kicked out of office due to an election recall spurred by voter anger over a water rate increase.[58]
- In addition to encouraging historic rates of consumption, persistent rate suppression may also starve reserve funds, critical to protecting investors from revenue volatility, as well as maintenance funds necessary to protect system performance.

While many utilities in areas of high water stress are taking steps to conserve scarce resources, conservation goals often are pursued alongside ambitious new supply projects that support continued high per capita consumption.

- Most large utilities are transitioning to pricing structures that begin to reflect their increasing marginal supply costs. Many also incorporate conservation into their resource planning, and have programs in place to reduce per capita consumption by pushing through ordinances requiring low-flow fixtures, paying residents to replace water-intensive turf grass with drought-resistant landscaping and offering rebates for water-efficient appliances. Yet for the most part, a review of bond documents and resource plans indicates that utilities in the most water stressed regions continue to pursue relatively modest conservation goals alongside ambitious supply augmentation projects to support per capita consumption far above the national average.

55 Annual Debt Service (ADS) is the ratio of annual debt obligations (principal and interest) to revenue. An ADS of 1.1, meaning revenue 10% higher than debt payments, is typically considered to be a minimum ratio for investment-grade debt. “All-in ADS” includes all principal and interest obligations for senior and subordinated debt.

56 Brett Walton, “The Price of Water: A Comparison of Water Rates, Usage in 30 U.S. Cities,” *Circle of Blue*, April 26, 2010, http://www.circleofblue.org/waternews/2010/world/the-price-of-water-a-comparison-of-water-rates-usage-in-30-u-s-cities/

57 Fitch, 2010.

58 Michael Cooper, “Recalls become a hazard for mayors,” *New York Times*, September 22, 2010.

Supply projects with high marginal costs can limit a utility's financial flexibility and reduce the financial incentive to conserve.

- Capital projects are financed on the expectation that revenues in the service area will grow or stay fixed over the lifetime of debt service. While utilities can set rate structures that allow them to simultaneously grow revenue and suppress consumption, decoupling revenue streams from increasing gallons delivered[59] debt repayment for high-capital supply projects can pin utility financial health to high-population and consumption growth. When utilities raise significant debt to finance new supply projects, there may be little incentive to price for conservation—utilities may implicitly encourage high consumption rates to pay back the debt incurred to enable consumption.
- Differences between projected and actual consumption growth can result in lower debt service coverage unless utilities increase rates. In some areas, utilities have been forced to increase rates to make up for unrealized growth stymied by the economic downturn.

Few utilities are planning for the effects of climate change, and those that are face significant uncertainty.

- Of the 53,000 public water systems in the United States, comparatively few have begun incorporating climate change into their long-term resource planning. Associations like the Water Utility Climate Alliance (WUCA) and the Association of Metropolitan Water Agencies (AMWA) are pushing forward best practices for planning for the effects of climate change on water supply reliability, stormwater flows, and water treatment demands.
- But existing climate models only can simulate future hydrology at a low level of resolution and with a high degree of uncertainty. While these tools are still useful in helping water resource planners to gauge the range of possible futures, assessments of the reliable yield of existing and proposed supplies are inherently uncertain given a changing climate regime. Yet today, neither bond official statements nor resource planning documents reflect this uncertainty when discussing the yield of existing or proposed supplies.

When utilities raise significant debt to finance new supply projects, there may be little incentive to price for conservation—utilities may implicitly encourage high consumption rates to pay back the debt incurred.

HISTORICAL CREDIT DOWNGRADES

Despite the generally rosy outlook conveyed by average credit ratings in the water utility sector, recent credit actions, and sector-specific analysis show significant risk of future credit volatility.

In recent years, there have been numerous credit downgrades precipitated by stresses to urban water systems and slowed growth. Downgrades from Fitch, for example, increased from five in 2007 to 15 in 2009.[60]

Still, the rating industry's approach to integrating water supply as a risk factor remains highly uneven, as illustrated by the following examples:

- In 2003, Moody's downgraded $1.7 billion of debt from Atlanta's Water and Sewer System Revenue Bonds from A2 to Baa1, indicating "moderate credit risk" from obligations that "may possess certain speculative characteristics."[61] As of 2010, Moody's had upwardly adjusted the rating to A1, considered to be "upper-medium grade" and "subject to low credit risk." Yet Atlanta faces the very real risk of losing nearly 40 percent of its water supply in a few years' time, based on a 2009 judicial order.[62]

59 Brett Walton, "U.S. Urban Residents Cut Water Usage; Utilities are Forced to Raise Prices," *Circle of Blue*, April 19, 2010, http://www.circleofblue.org/waternews/2010/world/u-s-urban-residents-cut-water-usage-utilities-are-forced-to-raise-prices/

60 Fitch Ratings, "2010 Water and Sewer Sector Retail Medians and Outlook," April 8, 2010.

61 Moody's, "Moody's Assigns Baa1 Rating and Stable Outlook to City of Atlanta's (GA) $454 Million Water and Wastewater Revenue Bonds, Series 2009B," October 7, 2009.

62 "State's water debate now in Congress' hands," *Atlanta Journal Constitution*, July 18, 2009, http://www.ajc.com/news/atlanta/states-water-debate-now-94877.html

- In 2009, the Metropolitan Water District (MWD) of Southern California received a negative credit outlook from Fitch based on legal constraints to the wholesale provider's water supplies.[63] Yet during the same year, Moody's rated water revenue bonds of San Diego's Water Enterprise "A1", relying in part on the assumption that the city will "have sufficient capacity for the foreseeable future."[64] San Diego secures around 80 percent of its water supplies from MWD.

RISKY ASSUMPTIONS MADE IN WATER UTILITY CREDIT ANALYSIS

Today's credit rating methods often obscure the vulnerability of water utilities to water risks, and may even discourage utilities from taking necessary steps to manage a sustainable system. A review of credit risk assessment methodology by Standard & Poor's, Moody's, and Fitch revealed the risky assumptions made in water utility credit analysis:

Utilities seeking credit ratings are not asked to submit plans for securing revenue during times of shortage.

- ***Water flows are assumed to be consistent with the recent past***. While rating agencies sometimes assess sufficiency of water supplies or costs of water-related environmental compliance, that analysis is highly regionally constrained, and rarely considered as a quantitative factor. Unless a utility is in the midst of drought, credit ratings typically do not consider the revenue effects of natural reductions to water supply, or the likelihood of such reductions.

  Utilities seeking credit ratings are not asked to submit plans for securing revenue during times of shortage consistent with the drought of near-term record, let alone deeper droughts in the longer-term record. Generally, utilities provide revenue projections for the next three to five years based on the water sales from the *previous* three to five years.

  If a utility has experienced severe drought in the past decade, rating opinions may consider how the utility fared during that period of shortage. Some credit rating agencies may refer to 12-month federal hydrological forecasts to consider potential for supply shortages. But generally, supply and revenue projections provided by utilities are not compared against independent estimates. No rating agencies reported having conducted an analysis of climate variability over the long-term historic record or the potential effects of climate change trends on the yield of capital projects.

- ***Rating agencies do not stress test utility systems to understand revenue effects of manmade supply shocks.*** The supply projections submitted by utilities in their three-year prospectus are not stress-tested to consider potential rate or revenue adjustments during times of supply disruption. This is true even for systems where judicial orders have stemmed substantial proportions of water supplies or where reasonably probable supply shocks hover in the three-year rating horizon.

- ***Water constraints are not assessed across the supply chain between wholesale and retail providers.*** The standard by which rating agencies determine supply stress is unevenly applied to wholesale and retail systems. In the western states especially, water shortages and escalating supply costs encountered by wholesale providers will trickle down to retail providers. As in other sectors, supplier risks can affect investors, meaning that risk assessment should extend down the supply chain.

63 Fitch Ratings, "Metropolitan Water District of Southern California," January 12, 2009.

64 Moody's, "Moody's Assigns A1 Rating to Water Revenue Bonds of San Diego, CA," June 14, 2009.

- ***Under current credit rating metrics, conservation pricing and demand-side management are as likely to impair credit ratings as to strengthen them.*** Pricing is a critical tool for controlling water demand, and managing demand is critical to minimizing marginal supply costs and avoiding unnecessary capital expenditures to increase supply. Yet today, unless a utility is in the midst of severe supply constrictions, credit agencies are almost hostile to conservation pricing and demand-side management.

  There are two reasons for this: 1) credit rating agencies rate utilities on their ability to grow revenue, and 2) rating agencies mistakenly assume that pricing water based on the true cost of each gallon delivered will reduce consumer demand so much that utility revenue will be insufficient to meet debt payments.

  Years of real-world experiments in conservation pricing show that utilities can meet debt obligations and manage demand at the same time. The relative price inelasticity of water[65] means that higher rates can play a role in managing demand while maintaining or increasing revenue.[66] And while consumers sometimes do respond more strongly than anticipated to higher prices, some utilities have learned to secure revenue by imposing a mixture of fixed fees to cover fixed costs and variable fees to communicate the increasing supply cost of additional water delivered.[67]

  Rather than rewarding conservation pricing in their credit rating metrics, however, rating agencies instead benchmark a utility's rates to the rates assessed in the surrounding region. For example, Fitch considers combined water and sewer service higher than two percent of median household income to be burdensome, unless that percentage is consistent with the regional benchmark.[68]

  In order to secure favorable credit ratings, utilities may seek to maintain parity with the benchmark, even if the consequence is failure to manage demand for increasingly costly supplies or to generate sufficient revenue for ordinary repairs.

Water stress can take its toll on utilities' short-term liquidity and long-term leverage. For ratings to convey a water utility's true credit risk, the rating opinion must incorporate the system's reliance on increasing consumption and its vulnerability to water stress. Today's credit ratings fail to incorporate these metrics consistently throughout the sector, leaving investors with insufficient information to manage their exposure.

The relative price inelasticity of water means that higher rates can play a role in managing demand while maintaining or increasing revenue.

Credit Risks for Public Electric Utilities

Years of deferred maintenance for transmissions and distribution networks are straining the nation's energy systems. Much of the electric grid was constructed 50 years ago with components designed to last 50 years.[69] Today, economic costs of power disruptions caused by outdated transmission systems range each year from $25 billion to $180 billion.[70] While significant investment is needed in transmission and distribution infrastructure to maintain a reliable grid, little attention is being paid to another fundamental vulnerability of the electric power system: its water intensity.

65 Price elasticity for residential water use is estimated to lie within the range of 0.35 to 0.45, meaning a 10 percent increase in price would produce a 3.5-4.5% reduction in demand (see Mitchell 2009).

66 David Mitchell and Tom Chesnutt, "White Paper: Water Rates and Conservation," March 31, 2009.

67 Brett Walton, April 19, 2010.

68 Fitch, 2008.

69 Causey, Warren, "Transmission Strains," *EnergyBiz Magazine*, January/February 2010.

70 ACSE, 2009.

Lowering an intake structure to capture low-flowing water can run upward of $200 million to lay the massive concrete pipes that are as long as a mile in length.

EXISTING FINANCIAL TRENDS LIMIT UTILITIES' ABILITY TO MANAGE WATER RISK

Across the country, thermoelectric power plants are facing steep capital costs to switch to less water-intensive cooling systems, sometimes as a result of regulatory pressure and sometimes because water supplies are no longer reliable.

The cost of adapting a cooling system to new water stresses varies widely. Lowering an intake structure to capture low-flowing water can run upward of $200 million to lay the massive concrete pipes that are as long as a mile in length.[71] Replacing a once-through cooling system with a less water-intensive model is exponentially more expensive. An estimate of replacement costs for investor-owned nuclear facilities tagged the cost for a single facility from as little as $189 million to as much as $4.5 billion—equal to $300 to nearly $2,000 per kilowatt.[72] The ability of utilities to pass through the cost varies widely—an estimate of investor-owned utilities (IOUs) found the capital cost to install cooling towers ranged from as little as zero percent to as much as 33 percent of the rate base.[73] While a similar calculation has not been done for public power utilities, it is clear that they stand to bear significant costs—either from retrofitting their own facilities or from assuming the passed-through cost of IOU power providers.

Yet the cost of not undertaking these actions can also be substantial—a few days of reduced power production from a heat wave that drove up water temperatures at the Tennessee Valley Authority's Alabama facilities are estimated to have cost the utility $10 million in lost power sales. Buying power on the spot market to make up for water-related generation reductions can cost a utility ten times as much per kilowatt-hour as the cost of generation—contingency costs that may not always be passed through to customers and may remain on utilities' balance sheets.

Losing a facility's operating permit also presents serious risks as states assert their authority under the Clean Water Act by predicating permit renewal on the installation of less water-intensive cooling structures. In the past year, both California and New York—home to eight percent of U.S. power production—have made moves to require steam turbine plants to install less water-intensive cooling systems.[74] In at least one instance—Entergy's Indian Point nuclear plant on the Hudson River—an existing facility has been denied a permit renewal because of the existing cooling water system's effect on aquatic organisms.[75]

The following sector-wide trends represent some of the challenges electric utilities will face in financing investments to reduce water stress:

Electric utility debt is expected to increase.

- Aging infrastructure, including transmission and distribution facilities, is expected to necessitate further debt financing.
- Environmental compliance will require significant costs to upgrade or retire generation sources.

Utilities' ability to pass through costs to consumers will be challenged.

- Maintaining historical debt ratios will hinge on the continued ability to pass through rate increases to consumers in the form of base rate increases.
- Political resistance to electricity rate hikes and diminished consumer credit may impair utilities' ability to pass through all costs, potentially reducing liquidity.

71 Mitch Weiss, "Drought Could Force Nuclear Plants to Shut Down," *The Associated Press*, January 23, 2008, http://www.wral.com/news/state/story/2343605/
72 Bernstein, 2010.
73 Ibid.
74 Ibid.
75 Wald, 2010.

Current debt capacity is low for wholesale and cooperative systems.

- Liquidity ratios tend to be weakest for wholesale power providers and generation and transmission cooperatives. All-in Annual Debt Service (ADS)[76] is around 1.17 for wholesale systems and 1.32 for cooperatives, compared to 1.96 for retail self-generating.[77]
- Many systems are bound by legal covenants requiring a minimum ADS of 1.1-1.3 (meaning that revenues are 110-130 percent of annual principal and interest payments), not far from projected near-term ratios, leaving little room for additional debt financing for some providers in the sector.

Most utilities have some degree of external water supply risk.

- With the exception of the largest wholesale power providers, most utilities secure some of their supply from market purchases or shared generation facilities, creating exposure to their suppliers' risks.
- Utilities of all sizes may purchase power on the spot market to replace power deficits. Spot prices are highly sensitive to demand and supply pricing trends, including regional competition for power during peak seasons and sector-wide production shortages.
- For wholesale providers, pre-existing power purchase agreements may further reduce utilities' ability to manage cash flow challenges, as they may be required to continue selling power at a fixed rate despite the increased cost of operation posed by environmental regulation or higher prices on the spot market.[78]

Utilities have varying commitment to managing demand.

- While many electric utilities now pursue demand-side management through energy efficiency programs, a utility's commitment to sustained efficiency gains as a means of reducing the need for generation expansion varies.

RISKY ASSUMPTIONS MADE IN ELECTRIC UTILITY CREDIT ANALYSIS

With the exception of hydropower producers, credit rating methods for electric utilities do not factor in water risks. Direct interviews and reviews of credit risk assessment methodology by Standard & Poor's, Moody's and Fitch revealed the limits of water as a credit risk factor in electric utility credit analysis.

- ***Sufficient water volume is generally assumed to be available for generation.*** While rating agencies sometimes assess sufficiency of water supplies for electric power production, that analysis is highly constrained to specific regions and generation sources. Rating agencies routinely review projected seasonal and annual stream flows for hydroelectric systems in the Pacific Northwest, yet stream flow analysis is not necessarily applied to hydro-heavy utilities in the Southeast despite significant variability in recent decades.[79]

  Flows for thermoelectric cooling are not considered in rating opinions or sector trend analysis. Rating agencies do not consider how a generating facility's water rights may ensure or compromise supply in times of shortage. Nor do they consider utilities' water intensity of power generation or the vulnerability of individual facilities' cooling water intake structures to changes in streamflow.

Flows for thermoelectric cooling are not considered in rating opinions or sector trend analysis.

76 Annual Debt Service (ADS) is the ratio of annual debt obligations (principal and interest) to revenue. An ADS of 1.1, meaning revenue 10% higher than debt payments, is typically considered to be a minimum ratio for investment-grade debt. "All-in ADS" includes all principal and interest obligations for senior and subordinated debt.

77 Fitch Ratings, "U.S. Public Power Peer Review Study," June 2009.

78 Standard & Poor's, "Western U.S. Hydroelectric Production Takes a Dive, and Utilities Adjust," August 5, 2004.

79 For example, between 2009 and 2010, Q1 hydropower generation dropped significantly in the Pacific Northwest (-15.4%) and Mountain West (-13.7%) and increased significantly in the South Atlantic (70.8%), illustrating the tremendous yearly variability in the hydropower sector.

- ***Vulnerability to temperature-related shutdowns is not considered.*** Rating agencies do not incorporate water temperature-related shutdowns into sector analysis, even though it is a growing cause of production shortages for thermoelectric facilities. Utilities with base load facilities cooled by open-loop systems are not tested for their sensitivity to water temperature increases, even those that have experienced repeated shutdowns of thermoelectric facilities due to heightened water temperatures (see **Appendix A** for more on cooling systems). As illustrated by recent temperature-related shutdowns at TVA coal and nuclear facilities, even a short heat wave can cost utilities millions of dollars in lost power sales. As temperatures rise from climate change, vulnerable facilities can be expected to experience more disruptions.
- ***Water-related environmental compliance costs are not factored into rating outlooks.*** Despite emerging regulations expected to pose high capital costs to water-intensive thermoelectric facilities (see **Appendix B**), credit rating agencies do not consider the proportion of a utility's power generated at once-through cooled facilities. Yet utilities whose base load facilities are cooled by once-through systems are at significantly more risk than those with less water-intensive base load plants—in terms of the cost to retrofit those facilities, the cost of reducing generation during peak seasons, and the cost of potentially having that facility forced into early retirement due to regulatory action.

For ratings to convey an electric utility's true credit risk, the rating opinion must incorporate the system's water intensity and its vulnerability to water stress. Today's credit ratings fail to incorporate these metrics consistently throughout the sector, leaving investors with insufficient information to manage their exposure.

Water stress can take its toll on utilities' short-term liquidity and long-term leverage. For ratings to convey an electric utility's true credit risk, the rating opinion must incorporate the system's water intensity and its vulnerability to water stress. Today's credit ratings fail to incorporate these metrics consistently throughout the sector, leaving investors with insufficient information to manage their exposure.

Risk Exposure for Public Utility Investors

Since utilities rely on sales revenue to service outstanding debt, the ability to make projected sales is a critical concern to investors. Utilities that fail to factor water stress into pricing, debt reserves, and capital expenditures may find themselves in a vicious cycle of credit degradation, unable to make the necessary system investments to deliver services and increasingly reliant on tenuous rate adjustments and tax referenda to maintain their revenues.

For utility investors, risks to revenue may compromise the value of their investments in two ways. First, reduced revenues may compromise a utility's ability to make timely payments to bond holders. Second, diminished credit capacity of an issuer may result in a negative outlook or credit downgrade that may reduce the price of that debt on the secondary market.

DEFAULT RISK

Failure to incorporate all material emerging trends into resource planning can seriously damage a utility's ability to honor its debt obligations. Utilities can minimize risk to investors by capitalizing debt reserve funds. They can also minimize risk by integrating emerging trends such as climate change and increased competition for water into capital planning and long-term power purchase agreements to limit exposure in their own operations and in those of their suppliers.

Yet risk of default from imprudent capital expenditures is not unknown in the sector—one of the largest municipal defaults in history was triggered when the wholesale electric utility, Washington Public Power Supply System, failed to pay $2.25 billion in debt issued to construct two nuclear plants, resulting in 88 participating public utilities across the United States absorbing the cost or defaulting on their bond obligations.

Recent trends in the credit enhancement market underline the need to diligently assess the credit risk of municipal debt issuers. For years, a growing proportion of municipal debt was secured by credit enhancement products such as insurance policies that guaranteed timely payment of principal and interest for the duration of the issuance. But from 2005 to 2009, the percentage of new insured municipal debt issuances fell from 55 percent to 8.5 percent, as regulators restricted the activities of bond insurers that had incurred credit impairments in their forays into structured debt.[80]

Based on interviews with rating agencies, recent bond insurer credit downgrades have had little effect on municipal water or electric power utilities, many of which had high underlying ratings. However, the demise of the credit enhancement market has motivated many utilities to refund long-starved debt reserve funds. For nearly twenty years, it had been common practice for utilities to free up cash by opting for a surety bond over their own debt reserve fund. The return to underlying credit ratings may be of long-term benefit to investors and utilities, in terms of encouraging more aggressive management of credit quality by issuers and buyers alike. But it also sharpens the need for accurate credit risk assessments.

PRICE VOLATILITY ON THE SECONDARY MARKET

The vast majority of public utility debt currently on the market is long-dated, with more than 75 percent currently traded having more than ten years remaining until maturity, and more than 40 percent having more than 20 years remaining until maturity.[81] Investors may have exposure to risks that will unfold over the lifetime of the bond whether or not they hold to maturity, as credit changes or market recognition of risk may result in changes in bond prices on the secondary market at any point in a bond's lifetime. Whether an investor holds a bond to maturity or actively trades on the secondary market, the near-term and fast-evolving nature of water risk exposes investors both now and in the future. If the market does not price for water-related risks in the near-term, investors will not see pricing signals or ratings triggers. Yet such near-term inaction would likely translate into a sharper mid-term correction that could have market-wide effects. Investors who understand these risks will be able to protect their portfolios, or even profit, from this mispriced risk.

For both buy-and-hold and active investors, a bond's credit rating is a primary factor in the decision to buy or sell. For investors who hold to maturity, the credit rating is an indicator of the likelihood of an issuer to default on payments to investors. For investors that trade on the bond market, credit ratings influence the price the investor can receive on the open market. Yet increasingly credit ratings are not the only opinions that may affect the price at which an investor may be able to sell a bond. A growing number of investors are looking to credit ratings as just one indicator of an issuer's credit risk. If investors lose confidence in an issuer's rating, the market price may adjust without waiting for rating opinions to catch up.

As water stress deepens, the probability of vulnerable systems experiencing material credit degradation grows accordingly. When credit ratings and risk assessment fail to incorporate high-probability system shocks, the result can be sudden and unanticipated changes in credit quality.

Unexpected credit changes triggered by weakened financials can subvert liquidity or spread on the secondary market, especially if large issuers or broad regions experience credit changes in tandem. There can also be significant system contagion risks if the market loses confidence in a class of security, as was evidenced recently in the mortgage-backed security market.

As water stress deepens, the probability of vulnerable systems experiencing material credit degradation grows accordingly. When credit ratings and risk assessment fail to incorporate high-probability system shocks, the result can be sudden and unanticipated changes in credit quality.

80 Christine Richard and Darrell Preston, "Buffett's 'Dangerous Business' Grips Municipal Bond Insurers," *Bloomberg Businessweek*, February 19, 2010.
81 Municipal Securities Rulemaking Board, "2009 Fact Book," April 2010.

Incorporating Water into Credit Risk Assessment

Given recent and projected water stress trends, investors may discover competitive advantage by incorporating water risk into their credit risk analysis. In addition, as these risks become more material, fund managers may face fiduciary responsibility to manage and disclose them to investors, and potential litigation if they do not.

Taking this step will require investors to understand the water risk exposure of specific bond issuers, not simply the risk exposure of regions or sectors. Because water risk among public utilities is poorly disclosed, assessing an issuer's water risk exposure often will require collecting information beyond what is currently offered in official statements.

Some investors may be tempted to limit their exposure to water risk in the municipal debt market by screening out geographies with extreme water stress. Because material water risks are affecting utilities across the country, a simple geographic screen of water-stressed regions is not an optimal method for managing exposure. Geographic screening may leave investors with substantial exposure in unscreened geographies. It may also exclude issuers with sufficient rate setting, capital planning and water rights to manage water stress. Additionally, broad geographic screening may push up the cost of debt to issuers in water-stressed areas irrespective of their ability to manage water risks.

Limiting exposure by screening out water-intensive sectors similarly may disadvantage investors and issuers managing their risks. For example, screening out hydropower generators may help investors to limit exposure to liquidity challenges caused by increased variability in water flows and sector power sales. But the investor may still have exposure to liquidity problems in the thermoelectric generation sector caused by cooling water constraints and increased capital costs.

This report proposes a quantitative model outlined in Chapter Three for assessing water risk that can be implemented using information available to investors today in federal reports, bond statements, and system planning documents. Increased investor engagement on utility water risk exposure may prompt rating agencies to aggregate this data in a format useful to investors. Investor engagement may also motivate utilities to deepen their disclosure and management of these risks.

A MODEL FOR ASSESSING WATER RISK

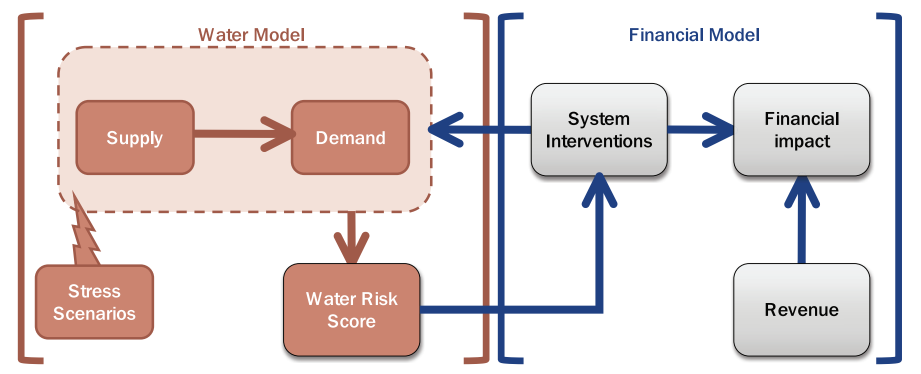
This report includes findings from an innovative quantitative model, developed by PwC, to help investors assess a utility's relative exposure and sensitivity to water risk. Drawing on public information gathered from federal reports, bond statements and utility planning documents, the model generates a ***water risk score*** that can be used by investors and credit rating agencies to better understand relative water risks among utility bonds. By coupling the water risk score with other financial information already available in credit rating opinions and bond documents, investors can gain a more complete picture of a bond's total risk profile. The water risk scores were designed to give a sense of the relative risk of undersupply of water over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk score is **not** an indicator of the likelihood of default.

As explained in the next chapter, in which the water risk model is applied to eight utility bonds, numerous financial factors can influence a utility's ability to respond to high water risks. Atlanta's water utility, for example, is shown to face the compounded challenges of high water risk scores and relatively low debt capacity, which may constrain its capacity to respond to potential long-term water undersupply. Alternatively, Phoenix has a higher water risk score than some of the other utilities modeled, but a higher debt service coverage ratio and lower water rates (see **Chapter Four** for more details).

The Water Risk Framework

The water risk model developed for the purposes of this report is meant to be used in a two-tiered framework that assesses a utility's relative exposure to water risk (the "Water Model") and the impact of this water risk on the overall credit risk of an issuer (the "Financial Model") (see **Exhibit 1**).

Exhibit 1: The Water Risk Model



This two-fold approach encourages water and power utilities, investors, and rating agencies to explicitly incorporate the vulnerability of the utility to water risk as well as the utility's financial health into their overall assessment of risk. Traditionally, decision-makers in the bond market have tended to focus only on financial metrics independent of a utility's fundamental water risk. However, this historic approach may no longer be adequate in identifying and addressing water risk in the debt market, due to increasingly complex and interrelated challenges such as climate change, increasing water demands, rising regulatory requirements, and aging infrastructure that may necessitate further capital expenditures or undermine a utility's ability to meet future debt payments.

The quantitative modeling carried out for the purposes of this report focuses on the Water Model, which can be integrated with traditional financial models to build a robust analysis for credit risk.

An Overview of the Water Model

The water model developed by PwC is a risk measurement tool that analyzes water supply and demand and estimates the risk of undersupply from 2011-2030, which parallels the overall lifetime of the bonds assessed in Chapter Four. The model incorporates socioeconomic, regulatory and physical factors that affect water supply and demand and considers how changes in these factors over time influence the potential risk of undersupply.

For both water and electric power utilities, water risk is defined as the risk that the utility's projected demand for water cannot be met by available supply. This risk of undersupply is articulated in a baseline "water risk score" (WRS) for each utility, which varies depending on the time horizon evaluated and the gap between available water supply and the utility's projected water demands. The higher the water risk score, the greater the risk of potential undersupply for that utility.

The water model compares supply and demand by using local water supply projections generated from the Water Evaluation and Assessment Project (WEAP), a software tool for integrated resources planning developed in collaboration with water utilities.[1] WEAP's projections are then constricted by the utility's legal water rights, and combined with water storage and any external water purchases to constitute the utility's available water supply.

1 For additional detail on WEAP, see http://www.weap21.org/

A Model for Assessing Water Risk

Total available supply is then compared to water demand projections. To account for uncertainty and randomness in long-term projections, the water model uses Monte Carlo simulations to generate a range of possible supply and demand outcomes by simulating each year hundreds of times. The projected undersupply and the water risk score are reported in terms of yearly averages, as well as possible extremes.

To assess the resilience of each system to stresses such as extreme drought and legal orders to reduce water withdrawals, a hypothetical set of stress scenarios was superimposed on the supply/demand model. The scenarios represent various levels of stress that may occur over the 20-year time horizon that was modeled. These "what-if?" scenarios are run through the model to give "stressed" water risk scores for each system, providing insights into the sensitivity of each system to changes in water supply and the key drivers of undersupply that would need to be addressed by interventions designed to manage this risk.

In this way, the water risk framework allows for a comparison of relative water risk over the lifetime of an issuer's debt obligation, as well as comparison of the relative risk between debt issuers.

WATER UTILITY METHODOLOGY

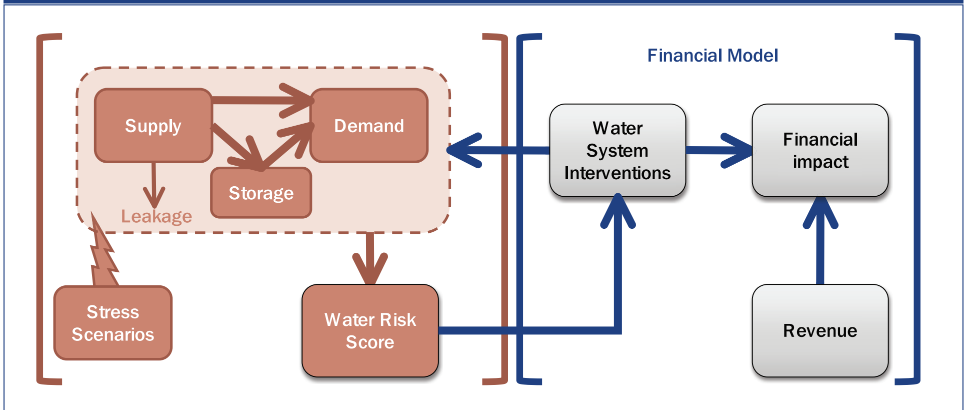
To quantitatively assess the utility's exposure to water undersupply, the model simulates the projected levels of monthly water flows from water supplies used by the utility and compares the available water to the utility's monthly demand.

- For ***water utilities***, water demand is defined as the demand among residential, commercial, and industrial customers in the utility's service area.

Local water supplies were assessed by first modeling physical surface water flows using the Water Evaluation and Assessment Project (WEAP).

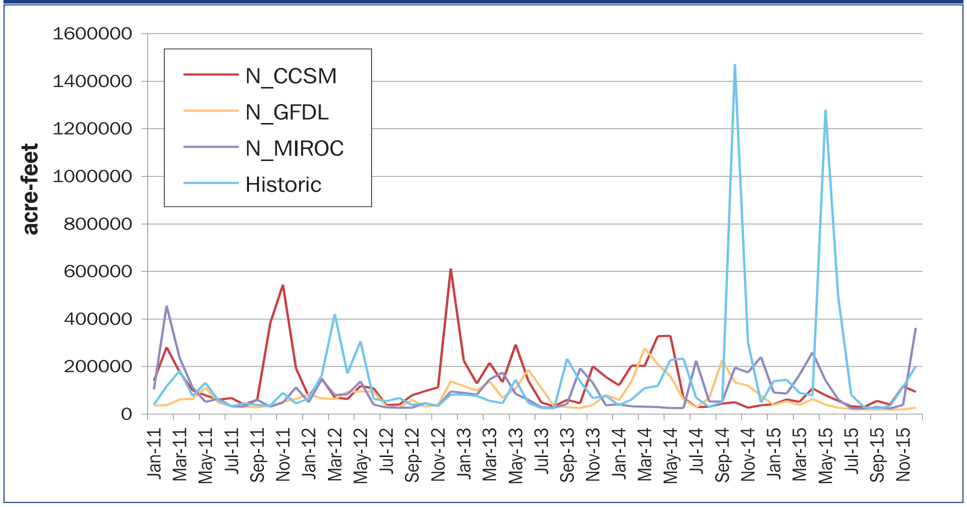
Physical flows were modeled using four different simulations of supply for each bond location, based on climate change scenarios taken from an archive of 112 state-of-the-art climate model projections over the contiguous United States (see **Appendix C** for more details). The four climate scenarios included: a reference scenario with no change from historical statistics, a wet scenario, a dry scenario, and a very dry scenario. For an example of how WEAP represents available water supplies under different scenarios, see **Exhibit 3**.

Exhibit 2: The Water Risk Model – Water Utilities



A Model for Assessing Water Risk

Exhibit 3: Trinity River Flows Using the WEAP Model



A representation of possible flows in the Trinity River near Dallas, Texas from January 2011 to November 2015, using the Water Evaluation and Planning (WEAP) model. Each trend line corresponds to one of the four climate scenarios employed in the model. Because the future is unknown, there is an equal probability of each scenario occurring over the modeled timeframe.

Available water flows in the utility's local supplies were further constrained by the utility's legal rights. For example, if physical flows in the utility's supply source ran at 3,500 acre-feet in a given month, but the utility had rights to only 3,000 acre-feet, the model would deliver only 3,000 acre-feet.

The next step was to calculate whether the projected water supplies from local sources is sufficient to meet future water demand. This was done by projecting and comparing the monthly supply and demand over the period 2011-2030 (see **Exhibit 2**).

For each monthly simulation in which water demand exceeded the supply of local water sources, the model deducted water from available storage capacity, such as reservoirs and groundwater supplies to which the utility has total or partial access. Storage deliveries were also constrained based on the utility's legal rights.

When monthly demand exceeded the utility's allotment from local sources and storage, external sources of water beyond the utility's political boundaries which the utility has a legal priority to purchase, or which the utility has historically purchased, were applied to meet the shortfall.[2]

Undersupply is realized when demand exceeds all disclosed available local supplies, storage and external sources currently in the utility's supply mix.

For each utility, an initial water risk score was assigned based on the utility's reliance on storage and external water imports to supplement local water in meeting demand. The model assigns higher risk scores to water utilities that rely heavily on storage and external water to satisfy demand (for more on how scores were assigned to each delivered source, see **Appendix C**). This established a ***baseline water risk scenario***, with its own annual score representing the extent of potential undersupply driven by projected demand and climate variability.

2 Unlike local sources and storage, water flows from external sources were not included in the WEAP modeling with respect to variability in natural flows. In reality, these sources are also subject to shortfalls from climate variability and climate change, making the assumption of available external supplies optimistic.

A Model for Assessing Water Risk

To understand the utility's resilience to external stresses on the system, including regulatory actions to protect environmental flows, legal challenges from other users or severe droughts on external water systems, ***stress scenarios*** were then applied to each of the utilities (see **Table 1**). For each stress scenario, a separate annual score based on the extent of the undersupply was assigned.

Table 1: Stress Scenarios for Water Utilities

Scenarios	Impact
Supply Reduction (High)	30% supply reduction for 3 years at most significant source
Supply Reduction (Low)	10% supply reduction continuously after impact at most significant source
Storage Reduction	50% capacity reduction in storage for 5 years
Storage + Supply Reduction	30% supply reduction for 3 years at most significant source + 50% capacity reduction in storage for 5 years

In each simulation, a risk score was assigned for each month of undersupply under baseline and stress scenarios, and the monthly risk scores were then tabulated for all years to 2030. In this way, risk scores may be compared between utilities and between stress scenarios for a single utility. For more on risk scoring, see **Appendix C.**

ELECTRIC UTILITY METHODOLOGY

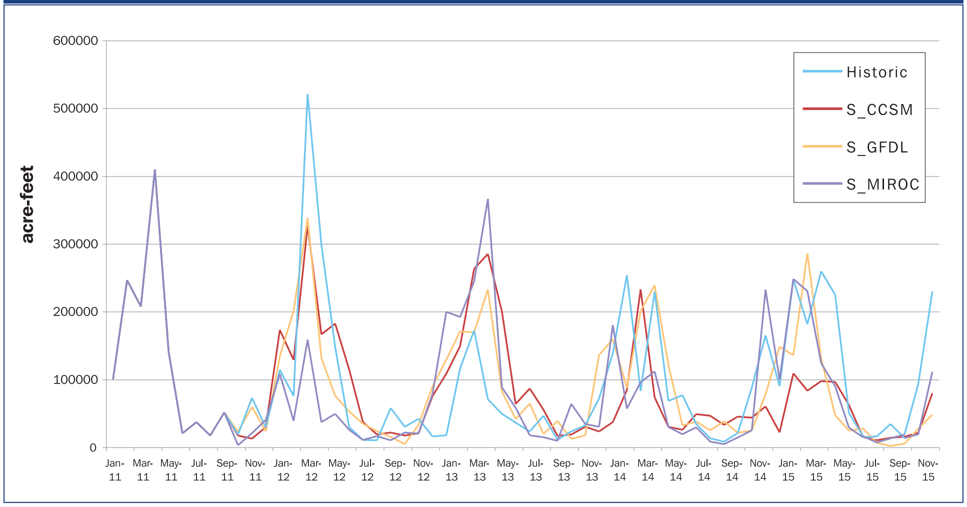
To quantitatively assess an electric utility's exposure to water undersupply, the model simulates the projected levels of monthly water flows from water supplies used by the utility and compares the available water to the utility's monthly demand.

- For ***electric utilities***, water demand is defined as the total water required by the utility to deliver electricity. This includes the electricity generated at the utility's wholly- and jointly-owned facilities, in addition to electricity delivered to the utility under power purchase agreements when operating at its optimal annual capacity.

Water supplies were assessed by modeling physical surface water flows at each freshwater-dependent facility using the Water Evaluation and Assessment Project (WEAP).

Physical flows were modeled using four different simulations of supply for each bond location, based on climate change scenarios taken from an archive of 112 state-of-the-art climate model projections over the contiguous United States (see **Appendix C** for more details). The four climate scenarios included: a reference scenario with no change from historical statistics, a wet scenario, a dry scenario, and a very dry scenario. For an example of how WEAP represents available water supplies under different scenarios, see **Exhibit 4**.

Exhibit 4: Black Warrior River Flows Using the WEAP Model



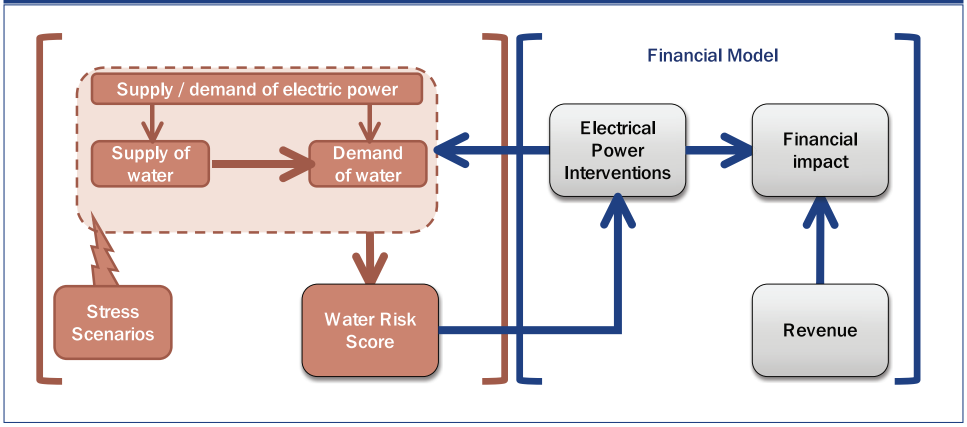
A representation of possible flows on the Locust Fork of the Black Warrior River near Birmingham, Alabama from January 2011 to September 2015, using the Water Evaluation and Planning (WEAP) model. Each trend line corresponds to one of the four climate scenarios employed in the model. Because the future is unknown, there is an equal probability of each scenario occurring over the modeled timeframe.

When information on the facility's water rights was available, water flows were further constrained to reflect these legal rights. For example, if physical flows in the facility's supply source ran at 3,500 acre-feet in a given month, but the utility had rights to only 3,000 acre-feet, the model would deliver only 3,000 acre-feet.

The next step was to calculate whether the projected water supplies from local sources were sufficient to meet future water demand. This was done by projecting and comparing the monthly supply and demand over the period 2011-2030 (see **Exhibit 5**).

Undersupply is realized when water demand exceeds water supply.

Exhibit 5: The Water Risk Model – Electric Utilities



For each monthly simulation in which water demand exceeded the usable supply of water, the model assigned a risk score. **The model assigns higher risk scores to the electric utilities with higher proportions of total generation capacity affected by water stress** (for more on how scores were assigned to each facility, see **Appendix C**).

This established a ***baseline water risk scenario***, with its own annual score based on the extent of undersupply driven by projected demand and climate variability.

To understand the utility's resilience to stresses on the system, including regulatory actions to protect environmental flows, legal challenges from other users, or additional capacity added to the facility to meet growing electricity demand, ***stress scenarios*** were then applied to each of the facilities. For each stress scenario, a separate annual score based on the extent of the undersupply was assigned.

Table 2: Stress Scenarios for Electric Utilities

Scenarios	Impact
Supply Reduction (High)	30% reduction in water supply for 3 years
Supply Reduction (Mid)	30% reduction in water supply for 1 year
Supply Reduction (Low)	10% reduction in water supply for 3 years
High Demand	Facility operates at twice historic capacity, simulating effects of generation expansion
Low Demand	Facility operates at historic capacity

In each simulation, a risk score was assigned for each month of undersupply under baseline and stress scenarios, and the monthly risk scores were then tabulated for all years to 2030. In this way, risk scores may be compared between utilities and between stress scenarios for a single utility. For more on risk scoring, see **Appendix C.**

Reasons Why Model Results May Be Wrong

There are several reasons why the results from this model may not fully represent water risk for the water and electric power utilities assessed.

- **Storage volume does not reflect competing withdrawals during times of shortage.** Although WEAP represents water withdrawals by competing users in the simulations of natural flows, the projected storage volumes do not incorporate withdrawals by other users. During times of drought or lower than average precipitation, utilities are likely to rely on shared storage resources to meet shortfalls in water flows. Thus storage volume represented in the model may be higher than volumes during an actual event of similar duration and intensity.
- **Junior water rights are not constrained during times of shortage.** The model allows utilities with junior water rights to extract their maximum water allocation even during times of shortage, when it is likely they would have to surrender a portion of allocated water to users with senior claims.
- **Natural flows for external sources are not modeled.** To limit modeling requirements, the model does not simulate naturalized flows from watersheds and systems considered external sources (for example, flows and competing deliveries on the Colorado River are not modeled for Los Angeles, Glendale, AZ or Phoenix). Simulated deliveries of external water supplies therefore assume sufficient supply when in reality droughts or climate variability may reduce the availability of external water supplies.

- **Stresses are not applied simultaneously.** Some utilities are likely to experience multiple stresses at the same time. For example, water utilities in California and Georgia have experienced reductions in water supply from drought at the same time that water deliveries were reduced to sustain environmental flows for aquatic species. Similarly, electric utilities may see drought-induced reductions in water flow as well as spiking water temperatures, creating multiple pressures on cooling water. Simultaneous stresses are likely to compound pressures and reduce the flexibility of utilities to respond. In the model, stresses are applied separately in randomly selected years for better comparability between utilities. The only case of simultaneous stresses in the model is overlapping high supply stress and storage stress for water utilities.
- **Utility has access to additional water sources which were not included in the bond prospectus.** The additional water sources would not have been included in the model and therefore the water risk may be overestimated.
- **Cooling water intake structures may be more vulnerable to water stress than assumed.** Public information on cooling water intake structures for thermoelectric facilities is of inconsistent quality, making it difficult to assess risk. Resources describing facility intake structures are few in number, and often sparing in information provided—for example, while the depth of the structure may be reported, no point of reference is provided to know whether the measurement is taken from the top, bottom or middle of the structure or what diameter of pipe is used. Even where facility-level data is provided on intake structures, typically there is no information on whether the facility withdraws water directly from an adjacent river or from a holding pond. For the purposes of this report, it was assumed that intake structure depth, when reported, is measured from the bottom of the pipe. For river-cooled facilities, where the reported intake pipe depth is lower than river depth (suggesting that the water is withdrawn from a holding pond), the likelihood of water height dropping below the intake structure was not modelled, for lack of information on the geometry of the holding pond.

For full details of the methodology, see **Appendix C**.

CASE STUDIES: ASSESSING WATER RISK IN EIGHT UTILITIES

To illustrate how the model can be used, a set of eight investment-grade municipal bonds issued by public water and power utilities were selected and analyzed. The selected bonds were for utilities located in Alabama, Arizona, California, Georgia, and Texas (see **Table 1**), and were chosen based on the following criteria:

- **Region:** Bonds issued by utilities serving growing populations in areas experiencing increasing water stress;
- **Repayment Source:** Bond obligations paid through water or power sales revenues;
- **Maturity:** Bond repayment proceeds as far as possible to 2030;
- **Size:** Bond offering exceeds $40 million (an indicator of liquidity on the secondary market).

Table 1: Securities of Interest

State	City / Region	Revenue Fund	Series	Total Offering	Year of Maturity for Longest-Dated Tranche[1]	Yield of Longest-Dated Tranche	Total Amount of Longest-Dated Tranche
Alabama	State-wide	Power	2010A	$74,465,000	2037	4.70%	$24,745,000
Arizona	Glendale	Water	2007	$44,500,000	2027	4.75%	$3,570,000
Arizona	Phoenix	Water	2002	$220,000,000	2026	5.23%	$63,405,000
California	Los Angeles	Water	2007A	$295,895,000	2044	4.72%	$184,215,000
California	Los Angeles	Power	2007A	$528,755,000	2039	4.54%	$58,900,000
Georgia	Atlanta	Water	1999	$1,108,745,000	2038	5.21%	$402,860,000
Texas	Dallas	Water	2007	$678,480,000	2036	4.56%	$33,915,000
Texas	Tarrant County (Fort Worth)	Water	2006	$182,905,000	2029	4.51%	$22,265,000

1 Each tranche in a bond series is comprised of a set of bonds having the same maturity date, interest rate, and yield. A 30-year refunding bond series may have 30 tranches, one for each year of repayment.

Summary Results: Water Utilities

Among the six water utilities modeled, the Los Angeles Department of Water and Power received the highest baseline risk score—4,886 points—due to profound restrictions in local water supplies and the system's dependence on water imports to satisfy demand (see **Table 2**).

Table 2: Average Water Risk Scores – Water Utilities Assessed (2011-2030)

Water Utility	Water Risk Score – Baseline Scenario	Stress Scenario Scores			
		Supply Reduction - High (30%, 3 yrs)	Supply Reduction - Low (10%, 3 yrs)	Storage Reduction (50%, 5 yrs)	Supply Reduction - High + Storage Reduction
Los Angeles, CA	4,886	4,996	5,011	4,888	4,994
Atlanta, GA	4,572	4,572	4,572	NA	NA
Glendale, AZ	4,278	4,329	4,315	4,290	4,344
Phoenix, AZ	4,233	4,358	4,369	4,245	4,361
Tarrant County, TX	1,419	1,515	1,525	1,495	1,609
Dallas, TX	736	811	804	800	874

Los Angeles' risk score may be conservative, given its dependence on imported water from the over-allocated Colorado River, which now accounts for a quarter of LA's supplies.

The City of Atlanta received the second highest baseline water risk score, 4,572 points. Atlanta's high risk score is the result of a combination of relatively high water demand and nearly complete dependence on water from the Chattahoochee River. The Chattahoochee is impounded north of the city in Lake Lanier, a supply that is seriously jeopardized by a 2009 judicial order to reduce withdrawals to 1970s levels, which could amount to a supply reduction of more than 40 percent starting in 2012.

The risk scores for Phoenix and Glendale, AZ (4,233 and 4,278 respectively), like that of Los Angeles, may be conservative, given the utilities' dependence on imported supplies from the Colorado River, accounting for nearly half of the water used by both Arizona utilities. The relative risk of the Arizona water utilities may be tested in the coming year as the ongoing drought in the Colorado River Basin—now in its 11th year—may soon force the Bureau of Reclamation to reduce water deliveries to Arizona.[2]

Both Dallas and neighboring Tarrant County, TX received the lowest risk scores among water utilities. Yet these systems also demonstrate how different the vulnerability of adjacent utilities may be—Tarrant's undersupply risk may be more than double that of Dallas, due in large part to the utility's smaller storage rights and reliance on highly variable precipitation to meet demand.

Summary Results: Electric Utilities

Of the two electric utilities modeled, Alabama-based PowerSouth received a higher risk score than the Los Angeles Department of Water and Power (see **Table 3**). At 2,548 points, PowerSouth's score is primarily due to the system's vulnerability to increased water temperatures and lower flows in the Tombigbee River, the cooling water source for its largest coal-fired plant. The utility's bond received "A" ratings with stable outlooks from both Fitch and S&P last year.

2 Felicity Barringer, "Water Use in Southwest Heads for a Day of Reckoning," *The New York Times*, September 27, 2010.

The Los Angeles electric power system received a water risk score of 1,480 points—due in part to vulnerability to reductions in power generated at the Hoover Dam due to low water flows in the Colorado River Basin. The system may also see reduced power deliveries from two of its major coal-fired power plants in Utah and Arizona, where necessary water flows are in serious question.

In the interconnected world of water and energy, power reductions at Hoover Dam may also make LA's water supplies more expensive—the Metropolitan Water Agency of Southern California purchases more than 28 percent of Hoover's power to pump water to Los Angeles and other nearby cities.

Table 3: Average Water Risk Scores – Electric Utilities Assessed (2011-2030)

Electric Utility	Baseline Scenario	Stress Scenarios				
		High Supply Reduction - (30%, 3 yrs)	Mid-Supply Reduction - (30%, 1 yr)	Low Supply Reduction – (10%, 3 yrs)	High Demand Increase	Demand Decrease
PowerSouth (AL)	2,548	2,550	2,549	2,549	2,559	2,548
Los Angeles, CA	1,480	1,731	1,569	1,537	2,910	895

How to Interpret the Water Risk Scores

The water risk scores were designed to give a sense of relative water risk over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk scores were designed to give a sense of the relative risk of undersupply of water over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk score is **not** an indicator of the likelihood of default. When reviewing the risk score of a given utility, an investor should consider:

- ***How the utility's water risk score compares to other systems.*** All systems face some degree of risk; the risk score of a single utility should only be considered relative to other utilities of the same type.
- ***The role of demand in creating undersupply.*** The risk scores assume that demand for water will grow at historic rates—an assumption that can be tempered in reality by meaningful investments in efficiency. In fact, when water utility risk scores were calculated using demand estimates pre-dating the economic downturn, Atlanta's risk scores were as much as 68 percent higher than those shown here, because of subsequent lower consumption levels caused by the recession.
- ***The choices utilities have in adapting their systems to manage the risk.*** The model compares demand growth to a fixed system. In reality, utilities adapt their supply mix and customer demand over time. The choices utilities have for expanding supply or curtailing demand represent a wide spectrum of costs with varying degrees of uncertainty in returns.
- ***The financial capacity of a utility to manage the risk.*** A utility's ability to manage undersupply, whether by financing supply expansion or managing demand through water pricing, depends on its financial flexibility. Financial metrics such as the annual debt service coverage ratio, water rates, and credit rating are good indicators for the relative flexibility of that utility in managing risk (see **Table 4**).

Table 4: Integrating Financial and Water Analysis: A Comparison of Utility Risk Scores, Credit Ratings, and Debt Ratios

Utility	Baseline Water Risk Score	Credit Rating S&P / Fitch / Moody's (S)= Stable Outlook (N)= Negative Outlook[3]	Projected Debt Ratio in 2014[4]	Water Rate Benchmark[5]
Water Utilities				
Los Angeles, CA	4,886	AA (S) / AA+ (S) / Aa2	1.88	33
Atlanta, GA	4,572	A (N) / A (S) /A1	1.16	43
Glendale, AZ	4,278	AA (S) / — / Aa3	1.48	28[6]
Phoenix, AZ	4,233	AAA (S) / — / Aa2	2.33	34
Tarrant County, TX	1,419	AAA (S) / AA+ (S) / Aa1	0.92	28
Dallas, TX	736	AAA (S) / — / Aa1	1.50	8
Electric Utilities				
PowerSouth (AL)	2,548	A- (S) / A- (S) / A3	1.20	NA
Los Angeles, CA	1,480	AA- (S) / AA- (S) / Aa3	2.47	NA

A utility with a high water risk score and low debt capacity (as indicated by a debt service coverage ratio close to 1.0) may have more difficulty managing water risk than a utility with a similar risk score and a higher ratio of revenue to debt service costs. Similarly, a utility with a high risk score and relatively low water rates may be better able to reduce its water risk by raising water rates and managing demand compared to a utility with a similar risk score and relatively high water rates. Atlanta, for example, has among the highest water rates in the country and a relatively high debt burden—factors that may make its high water risks even more challenging to manage.

- ***Whether the investor is compensated for relative risk.*** Investors may be willing to accept higher water risk if the bond is structured to compensate for that risk, for example by a below par price or a higher coupon rate. Since undersupply risks are unevenly incorporated into credit ratings and bond statements, investors holding these bonds may not be compensated for their relative risk.

3 See Appendix D for the rating scales of the three rating agencies.

4 The annual debt service ratio is the ratio of revenue income to debt service outflows including principal and interest payments. The projected debt ratios in 2014 are estimates based on self-reported financials in utility bond statements and system-wide financial reports.

5 Based on Black & Veatch *50 Largest Cities Water/Wastewater Rate Survey 2009/2010.* Water rates are ranked from lowest water rates (1) to highest water rates (50).

6 Glendale was too small to be included in the Black & Veatch study. Its ranking is approximate and based on a comparison of the system's rates with the rates of ranked cities.

INTERPRETING THE WATER RISK SCORE

Interpreting the Water Risk Score

LEGEND: CONTRIBUTION TO WATER SUPPLY

Major contributions to the utility's supply, based on bond official statements.

AVERAGE WATER RISK SCORE

The baseline risk score indicates the likelihood of undersupply over the next 20 years given projected water consumption rates and available supplies in the system's existing supply mix.

*The water risk scores were designed to give a sense of the relative risk of undersupply of water over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk score is **not** an indicator of the likelihood of default.*

Los Angeles Department of Water and Power, Water Revenue Fund

Los Angeles

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
4,886
Stress Scenarios:
Supply Reduction - High (30%, 3 yrs)
4,996 | 2.25% | 17.42%
Supply Reduction - Low (10%, 3 yrs)
5,014 | 2.57% | 5.21%
Storage Reduction (50%, 5 yrs)
4,888 | 0.04% | 0.20%
Supply Reduction - High + Storage Reduction
4,994 | 2.22% | 6.94%

% = Average increase to risk score across 20-year period
% = Average impact of stress scenario on years affected

50

LOS ANGELES, CALIFORNIA

POPULATION SERVED

Los Angeles Department of Water and Power (LADWP) delivers water to 4.1 million people in greater Los Angeles.

WATER SUPPLIES

Although Los Angeles has access to a diverse local supply of surface and ground water, its usable amount has declined substantially in the past few decades, forcing the city to lean heavily on water imported by the Metropolitan Water District of Southern California (MWD).

Local supplies remain tenuous—deliveries from the Los Angeles Aqueduct are still constrained by the California State Water Resources Control Board to protect environmental flows in the Owens Valley and Mono Lake (for more, see page 22). Local groundwater supplies, which contribute a few percent of supply, remain restricted due to a migrating plume of industrial contamination.

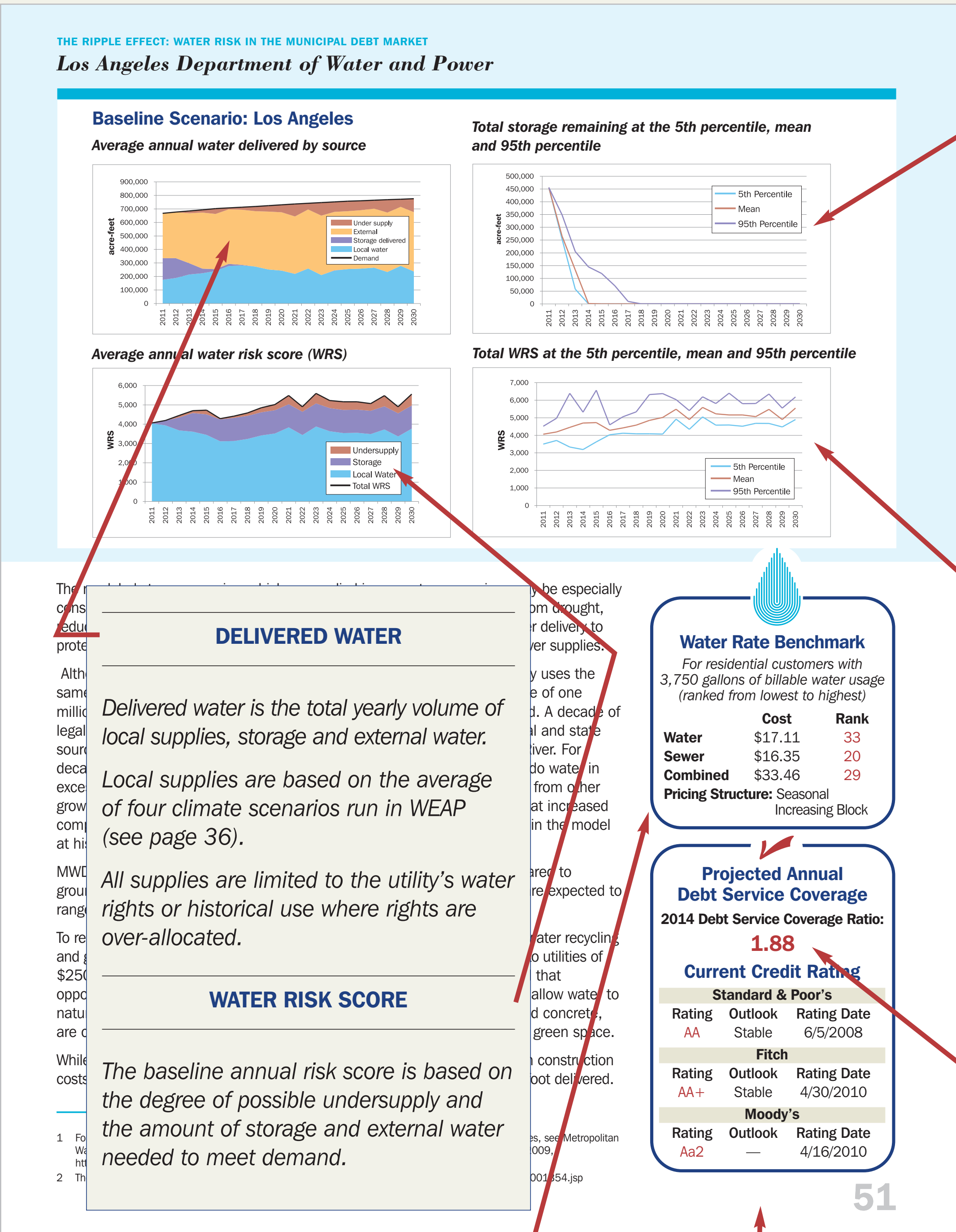
Recycled water constitutes one percent of the supply mix.

More than half of LA's water supply is now imported by the MWD from the waters of the Bay Delta and Colorado River. That supply is also subject to natural and legal constraints. In 2009, MWD deliveries to southern California fell by 40 percent from an ongoing drought and by another 25 percent to protect fish populations in the Bay Delta (for more, see page 22).

KEY RISKS

In all scenarios, Los Angeles far outstrips local supplies, and under projected climate scenarios and current water demand could experience undersupply from all sources by as early as 2013. Under current conditions, Los Angeles may exhaust its reliable storage by the end of the decade *(see Total storage remaining at the 5th percentile, Mean and 95th percentile)*.

Interpreting the Water Risk Score



Los Angeles Department of Water and Power

Baseline Scenario: Los Angeles

Average annual water delivered by source

Total storage remaining at the 5th percentile, mean and 95th percentile

Average annual water risk score (WRS)

Total WRS at the 5th percentile, mean and 95th percentile

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$17.11	33
Sewer	$16.35	20
Combined	$33.46	29

Pricing Structure: Seasonal Increasing Block

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.88

Current Credit Rating

Standard & Poor's		
Rating	Outlook	Rating Date
AA	Stable	6/5/2008
Fitch		
Rating	Outlook	Rating Date
AA+	Stable	4/30/2010
Moody's		
Rating	Outlook	Rating Date
Aa2	—	4/16/2010

51

DELIVERED WATER

Delivered water is the total yearly volume of local supplies, storage and external water.

Local supplies are based on the average of four climate scenarios run in WEAP (see page 36).

All supplies are limited to the utility's water rights or historical use where rights are over-allocated.

WATER RISK SCORE

The baseline annual risk score is based on the degree of possible undersupply and the amount of storage and external water needed to meet demand.

TOTAL STORAGE REMAINING

When water demand exceeds local supplies, the difference is made up via the utility's storage, which may be groundwater or surface water stored in reservoirs. Since supply and demand are simulated hundreds of times each month to capture the range of possible outcomes, the storage remaining each year may be as little as that represented by the 5th percentile of simulations or as much as that represented by the 95th percentile.

TOTAL WATER RISK SCORE

Because the model represents possible outcomes in an uncertain future, the extent of undersupply is not a fixed value. Undersupply is simulated hundreds of times for each month in the 20 years modeled, resulting in a total water risk score distribution representing the range of possible risk. In a given year, the water risk score may be as little as that represented by the 5th percentile or as high as that represented by the 95th percentile.

PROJECTED ANNUAL DEBT SERVICE COVERAGE

The estimated ratio of revenue to all debt payments, including principal and interest in 2014, based on self-reported financials in bond official statements and financial reports.

A ratio of 1.0 indicates that revenue will just equal debt payments, leaving no room for debt reserves, system maintenance, or new debt service. Utilities can increase revenue (and thereby boost the debt service ratio) by raising rates.

WATER RATE BENCHMARK

The utility's 2010 monthly water rate for residential customers, an indicator of the potential for conservation pricing.

#1 indicates lowest water rate among the 50 largest U.S. cities. #50 indicates the highest rate. Rankings are based on a sector survey by industry consultant Black & Veatch.

CURRENT CREDIT RATING

The most recent credit ratings for the utility's debt obligation of interest. This indicates the rating agencies' opinions of the likelihood of default.

See Appendix D for a guide to credit rating scales.

Los Angeles Department of Water and Power, Water Revenue Fund

Los Angeles

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

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More than half of LA's water supply is now imported by the MWD from the waters of the Bay Delta and Colorado River. That supply is also subject to natural and legal constraints. In 2009, MWD deliveries to southern California fell by 40 percent from an ongoing drought and by another 25 percent to protect fish populations in the Bay Delta (for more, see page 22).

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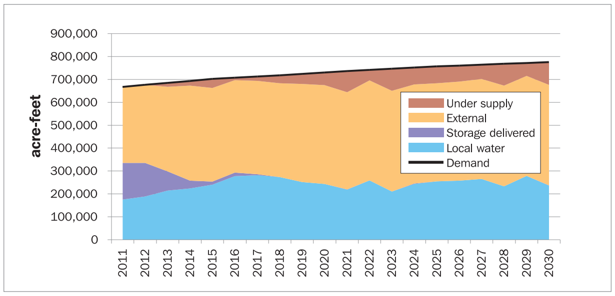
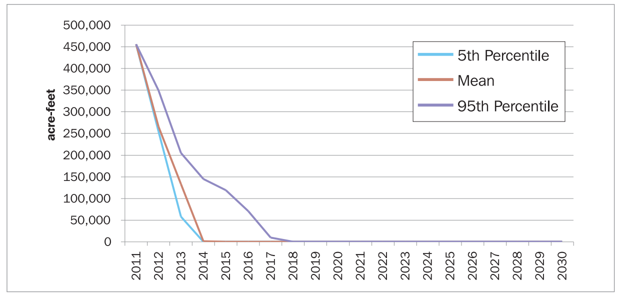
Los Angeles Department of Water and Power

Baseline Scenario: Los Angeles

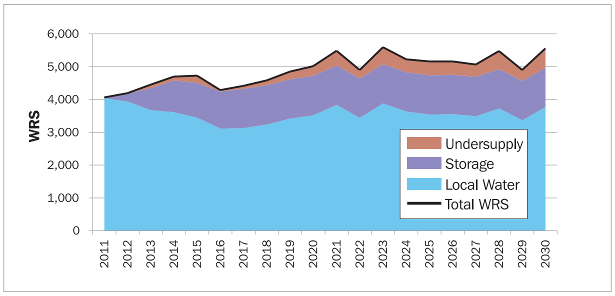
Average annual water delivered by source



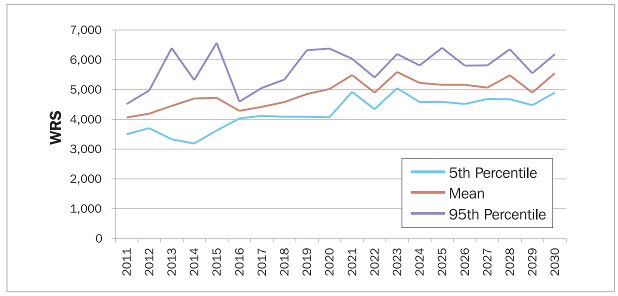
Total storage remaining at the 5th percentile, mean and 95th percentile



Average annual water risk score (WRS)



Total WRS at the 5th percentile, mean and 95th percentile



The modeled stress scenarios, which are applied in separate succession, may be especially conservative for Los Angeles, which already is subject to supply reductions from drought, reduced snowpack from warming temperatures, regulated reductions in water delivery to protect the Bay Delta ecosystem, and increased competition for Colorado River supplies.

Although LA has made significant inroads with water conservation—the city uses the same amount of water as it did 25 years ago, despite a population increase of one million people—the vulnerability of the system's water supply has increased. A decade of legal challenges and droughts has shrunk the system's reliable yield of local and state sources, increasing its dependence on imported water from the Colorado River. For decades, southern California has relied on the availability of surplus Colorado water in excess of the state's legal allocation to fuel growth. Increasing competition from other growing states is likely to reduce the reliability of that surplus.[1] To reflect that increased competition, the projected deliveries of Colorado River imports are capped in the model at historic purchase levels, even as supply from other sources fall.

MWD purchases are also a growing cost to the Los Angeles system. Compared to groundwater, which is $150/AF, purchased untreated supplies from MWD are expected to range from $414-495/AF by 2014.[2]

To reduce its risk, Los Angeles can focus on boosting local supplies through water recycling and groundwater replenishment, leveraging incentives such as MWD's rebate to utilities of $250 for each acre-foot of water recycled. Additionally, the system may find that opportunities for shared financing of groundwater recharge projects, which allow water to naturally return to aquifers by removing impervious surfaces like asphalt and concrete, are cost competitive if shared with other agencies also seeking to increase green space.

While ocean water desalination may seem cost competitive upfront based on construction costs, the energy intensity of this process may be less competitive per acre-foot delivered.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$17.11	33
Sewer	$16.35	20
Combined	$33.46	29

Pricing Structure: Seasonal Increasing Block

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.88

Current Credit Rating

Standard & Poor's

Rating	Outlook	Rating Date
AA	Stable	6/5/2008

Fitch

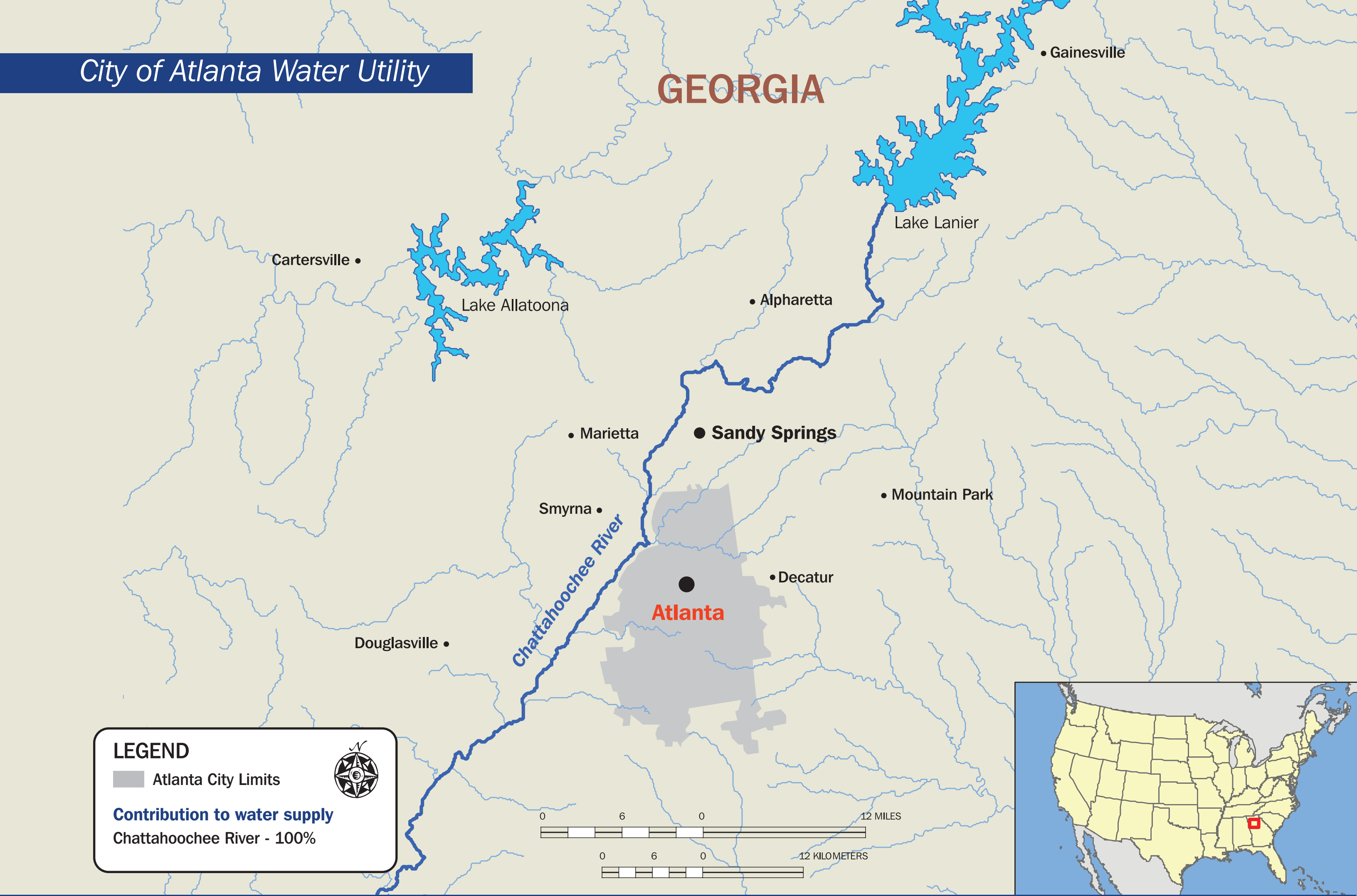
Rating	Outlook	Rating Date
AA+	Stable	4/30/2010

Moody's

Rating	Outlook	Rating Date
Aa2	—	4/16/2010

1 For more on California's basic apportionment of Colorado River water versus historical surplus purchases, see Metropolitan Water District of Southern California, "California's Colorado River Allocation," last updated March 18, 2009, http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/colorado/colorado04.html

2 The City of Los Angeles 2005 Urban Water Management Plan, http://www.ladwp.com/ladwp/cms/ladwp001354.jsp



Atlanta

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
4,572
Stress Scenarios:
Supply Reduction - High (30%, 3 yrs)
4,572 | 0.00% | 0.00%
Supply Reduction - Low (10%, 3 yrs)
4,572 | 0.00% | 0.00%
Storage Reduction (50%, 5 yrs)
NA | NA | NA
Supply Reduction - High + Storage Reduction
NA | NA | NA

% = Average increase to risk score across 20-year period
% = Average impact of stress scenario on years affected

ATLANTA, GEORGIA

POPULATION SERVED

The City of Atlanta Department of Watershed Management delivers drinking water and treats wastewater for more than a million people in the metropolitan Atlanta region. Significant accounts include Delta Airlines and The Coca-Cola Company.

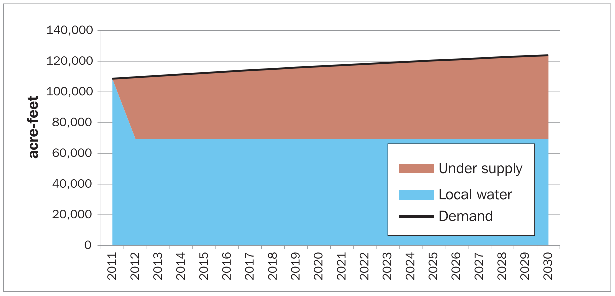
WATER SOURCES

The city relies predominantly on water from the Chattahoochee River impounded north of the city in Lake Lanier, a reservoir operated by the United States Army Corps of Engineers for the mutual benefit of Alabama, Florida, and Georgia. While the city has relied on the lake for over three decades, a federal judge has ordered the region to reduce its withdrawals to 1970s levels, which—according to the Georgia Environmental Protection Division—could amount to a supply reduction of more than 40 percent within a few years.

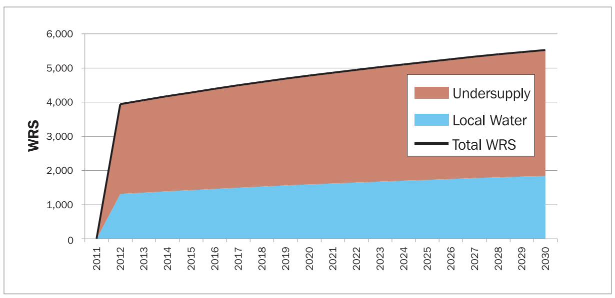
The system is estimated to lose about 15 percent of its water through leakage.

Baseline Scenario: Atlanta

Average annual water delivered by source



Average annual water risk score (WRS)



Loss of Lake Lanier supply is the key risk driver for the Atlanta system, and accounts for a significant increase in annual risk scores between 2011 and 2012.

KEY RISKS

Loss of Lake Lanier supply is the key risk driver for the Atlanta system, and accounts for the increase in annual risk scores between 2011 and 2012. While Georgia may be able to secure a higher proportion of Lake Lanier's volume in an interstate compact with Alabama and Florida, no agreement is expected among the states in the short-term. Similarly, while pending Senate bills may secure system supplies before the court's deadline, Atlanta's ultimate supply is unknown and Congressional action before the midterm elections may be unlikely. A 2009 Governor's task force found that construction of additional reservoirs would take at least eight years to complete, at a cost of hundreds of millions of dollars.[1]

Consequently, the model reduced useable water to 40 percent of historic average daily withdrawals between 2012 and 2030. Storage waters from the Hemphill Reservoir and Fulton Plant, which are also fed by the Chattahoochee River, were not considered.

Atlanta's stress scenarios produce virtually no difference in the risk score because of the reductions to supply stemming from the judicial order.

Atlanta's system has received considerable investment in recent years, with $2 billion spent since 2003 to comply with water quality standards, and an EPA consent decree mandating several hundreds of million more in upgrades to the city's wastewater system.

To finance these mandatory wastewater investments the city has tripled water and wastewater rates, imposed a one percent sales tax and financed $3.2 billion for capital investments.[2]

With substantial debt obligations, ongoing expenditures mandated by federal and state consent decrees, and one of the highest water rates in the country, the loss of a substantial portion of supply could be managed by boosting supplies from avoided consumption, and investing in green infrastructure projects to minimize stormwater runoff, critical for improving water quality.

1 "Water Contingency Task Force Presents Final Recommendations," State of Georgia Office of the Governor, Press Release, December 22, 2009.

2 City of Atlanta, "First Amended Consent Decree 1:98-CV-1956-TWT Financial Capability-Based Amendment & Schedule Extension Request," April 30, 2010.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$19.81	43
Sewer	$50.06	49
Combined	$69.87	49

Pricing Structure: Increasing Block

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.16

Current Credit Rating

	Standard & Poor's	
Rating	Outlook	Rating Date
A	Negative	2/25/2008

	Fitch	
Rating	Outlook	Rating Date
A	Stable	4/30/2010

	Moody's	
Rating	Outlook	Rating Date
A1	—	5/1/2010

Glendale

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
4,278
Stress Scenarios:
Supply Reduction - High (30%, 3 yrs)
4,329 | 1.19% | 8.87%
Supply Reduction - Low (10%, 3 yrs)
4,315 | 0.85% | 1.72%
Storage Reduction (50%, 5 yrs)
4,290 | 0.28% | 1.29%
Supply Reduction - High + Storage Reduction
4,344 | 1.53% | 4.74%

% = Average increase to risk score across 20-year period

% = Average impact of stress scenario on years affected

GLENDALE, ARIZONA

POPULATION SERVED

City of Glendale Water and Sewer System serves a quarter of a million people, 99 percent within the city's corporate limits. Most of the system's users are residences and municipal services including schools and hospitals.

WATER SUPPLIES

Glendale relies on a mix of local surface and groundwater along with imported water from the Central Arizona Project (CAP), a major transmission system that delivers Arizona's share of Colorado River deliveries to central Arizona. The Salt River Project (SRP), which delivers mountain runoff to eligible lands in the Phoenix metropolitan area, makes up more than 60 percent of Glendale's water supply, with CAP making up most of the remainder. The relative costs of its water varies widely; Glendale has paid more than seven times as much per acre-foot of CAP water than it has paid per acre-foot for SRP water. Most of the SRP water available to Glendale may only be delivered to lands with historic rights within the SRP-eligible lands. Though most of "off-project" demand is currently met with CAP supplies, Glendale does have some additional storage of non-SRP water from the Salt River on the SRP reservoir system, which can supplement CAP water in areas that are not SRP-eligible.

The system is estimated to lose about 10 percent of its water through leakage.

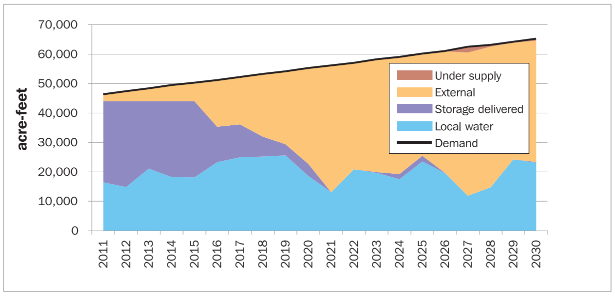
KEY RISKS

Modest storage rights in the Salt River Project and reliance on imported Colorado River supplies to feed consumption are the system's primary risk drivers.

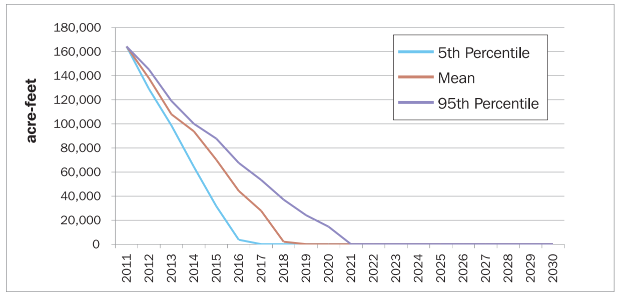
Glendale Water Utility

Baseline Scenario: Glendale

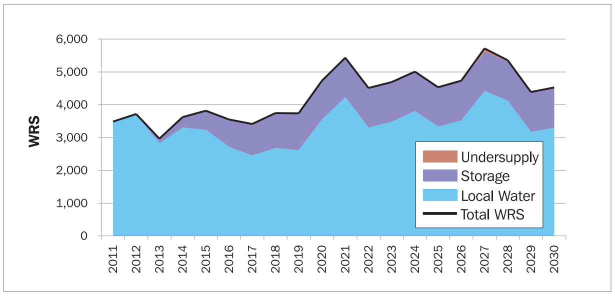
Average annual water delivered by source



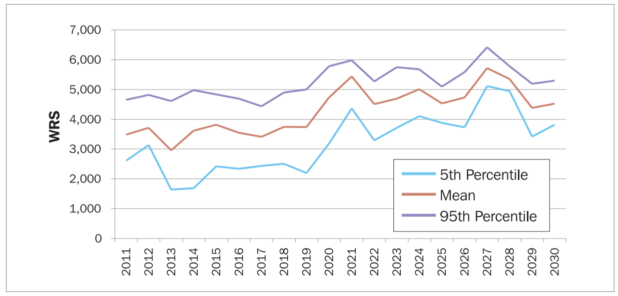
Total storage remaining at the 5th percentile, mean and 95th percentile



Average annual water risk score (WRS)



Total WRS at the 5th percentile, mean and 95th percentile



Glendale has rights to only about 12 percent of Salt River Project reservoirs and groundwater, making it especially vulnerable during times of low mountain snowfall. Because of its junior rights, SRP deliveries to Glendale during times of shortage may be reduced as municipalities with senior positions like Phoenix assert their claims—a condition that may substantially reduce deliveries to Glendale and increase undersupply beyond that projected. For this reason, Glendale's risk score should be viewed as conservative.

Based on simulations of supplies described in bond official statements, by 2021, and even as early as 2016, the system's SRP storage supplies may be exhausted as the system makes up for low flows on the SRP *(blue wedge)*, more than doubling dependence on costly CAP imports *(yellow wedge) (see Baseline Scenario: Total storage remaining at the 5th percentile, mean and 95th percentile)*.

The system may be vulnerable to changes in the yield and cost of Colorado River supplies, which could strain water availability for much of the state and put added pressure on the SRP.

When shortages are declared at Lake Mead—as may happen in the near term, as levels in that lake are only eight feet above the shortage level—the CAP portion of Arizona's 2.8 million acre-foot allocation is among the first of the lower basin contracts to see deliveries reduced. The "Law of the River" gives priority for CAP supplies to municipal users over agricultural users, reducing the likelihood that municipalities like Glendale will be the first to see reductions in CAP supplies. As all municipalities have equal priority to CAP water, however, the portion Glendale would receive depends on total demand. Groundwater stores of surplus CAP deliveries are therefore a crucial component of Glendale's resilience to future shortages.

The system can address its supply constraints through a combination of low-capital supply solutions, including transferring water from agricultural users, and strong demand-side management to increase revenue while suppressing per capita consumption from the current level of around 180 gallons/day. Glendale's plans to boost local sources, including groundwater via water reuse, will be integral to reducing its risk.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$16.00	28
Sewer	$31.29	44-45
Combined	$47.29	43-44

Pricing Structure: Increasing Block

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.48

Current Credit Rating

Standard & Poor's		
Rating	Outlook	Rating Date
AA	Stable	6/5/2008
Fitch		
Rating	Outlook	Rating Date
—	—	—
Moody's		
Rating	Outlook	Rating Date
Aa3	—	5/1/2010

Phoenix

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
4,233
Stress Scenarios:
Supply Reduction - High (30%, 3 yrs)
4,358 | 2.94% | 23.19%
Supply Reduction - Low (10%, 3 yrs)
4,369 | 3.20% | 6.51%
Storage Reduction (50%, 5 yrs)
4,245 | 0.27% | 1.22%
Supply Reduction - High + Storage Reduction
4,361 | 3.02% | 9.52%

% = Average increase to risk score across 20-year period

% = Average impact of stress scenario on years affected

PHOENIX, ARIZONA

POPULATION SERVED

The Phoenix Water System serves over 1.5 million people in metropolitan Phoenix.

WATER SUPPLIES

Phoenix relies on a mix of local surface and groundwater and a heavy supply of imported water from the Central Arizona Project (CAP), a major transmission system that delivers Arizona's share of Colorado River deliveries to central Arizona. The Salt River Project (SRP), which delivers mountain runoff to eligible lands in the Phoenix metropolitan area, makes up a little more than half of Phoenix's water supply, with CAP making up the majority of the remainder.

The relative costs of that imported water varies widely; as of 2008, Phoenix paid more than five times as much per acre-foot of CAP water as for SRP supplies. Most of the SRP water available to Phoenix may only be delivered to lands with historic rights within the SRP-eligible lands. Though most of "off-project" demand is currently met with CAP supplies, Phoenix is allowed to store some non-SRP water from the Salt and Verde Rivers and groundwater exchanges in SRP reservoirs, which can supplement CAP water in areas that are not SRP-eligible.

Though Phoenix has begun to supplement its supply by trading treated wastewater effluent for freshwater rights, this source currently contributes only a few percent of supply to the system. At this time, most of Phoenix's wastewater is contracted to serve power production, irrigation and wildlife habitat restoration uses in the region.

The system's water loss rate is around seven percent.

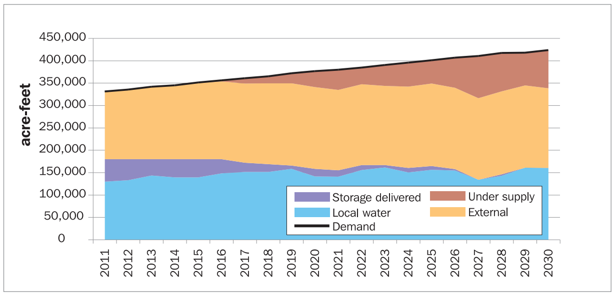
KEY RISKS

The system's risk score reflects a heavy reliance on imported supplies. Although Phoenix has senior rights to water flows and storage on the Salt River Project, much of the city's growth in the past 15 years has occurred on lands that are not SRP-eligible, bringing the city to rely heavily on water from the Colorado River. As SRP purchases have held steady,

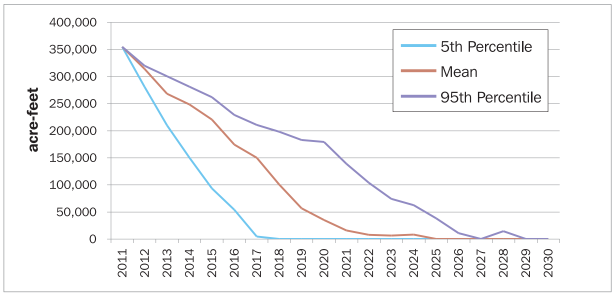
Phoenix Water Utility

Baseline Scenario: Phoenix

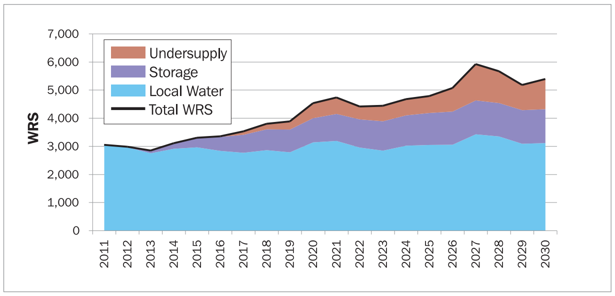
Average annual water delivered by source



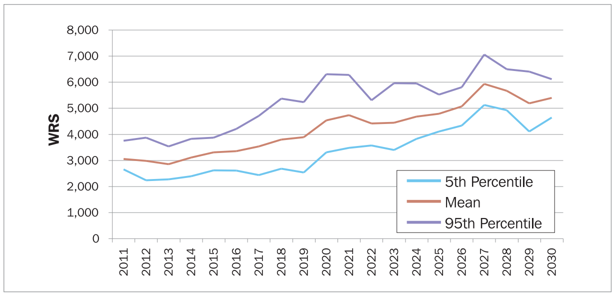
Total storage remaining at the 5th percentile, mean and 95th percentile



Average annual water risk score (WRS)



Total WRS at the 5th percentile, mean and 95th percentile



the system has tripled its purchases of CAP water. Such dependence on interstate deliveries from the Colorado River may make the system vulnerable to increased supply and price volatility. Its 2050 plan would maintain CAP deliveries at about 50 percent of its water use, even with additional supplies provided by its portfolio of stored water supplies, accumulated through groundwater recharge credits and water banking credits.

Phoenix also could offset future shortages or increased costs of CAP supplies by claiming more of its SRP water in the future. The city is entitled to twice as much SRP water as it currently uses, meaning that in times of shortage, Phoenix can assert its claim to waters typically delivered to other SRP users. But its senior water rights do not completely eradicate risk from undersupply of local waters and storage, as the reallocation of water from neighboring municipalities would be subject to political uncertainty.

When shortages are declared at Lake Mead—as may happen in the near term, as levels in that lake are only 8 feet above the shortage level—the CAP portion of Arizona's 2.8 million acre-foot allocation is among the first of the lower basin contracts to see deliveries reduced. The "Law of the River" gives priority for CAP supplies to municipal users over agricultural users, reducing the likelihood that municipalities like Phoenix will be the first to see reductions in CAP supplies. As all municipalities have equal priority to CAP water, however, the portion Phoenix would receive depends on total demand. Groundwater stores of surplus CAP deliveries are therefore a crucial component of Phoenix's resilience to future shortages. Without considering stored CAP water credits, high supply stress to CAP deliveries on average caused Phoenix's risk score to increase by 25 percent.

In model simulations, variability of local supplies from runoff in the Salt and Verde Rivers, coupled with historic rates of consumption, may drive down SRP storage—under some simulations exhausting reliable SRP storage by 2017 *(see Baseline Scenario: Total storage remaining at the 5th percentile, mean and 95th percentile).*

Phoenix's efforts to manage these risks by boosting local supplies through transferring water from agricultural users, water recycling and groundwater replenishment are critical to maintaining a resilient system. The city's efforts toward avoided consumption is another strong source of supply—yet even though historic demand management has reduced per capita consumption to 190 gallons/day, Phoenix must make significant inroads to maximize this resource. One key step may be stronger conservation pricing.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$17.29	34
Sewer	$13.46	16
Combined	$30.75	21

Pricing Structure: Uniform Seasonal

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

2.33*

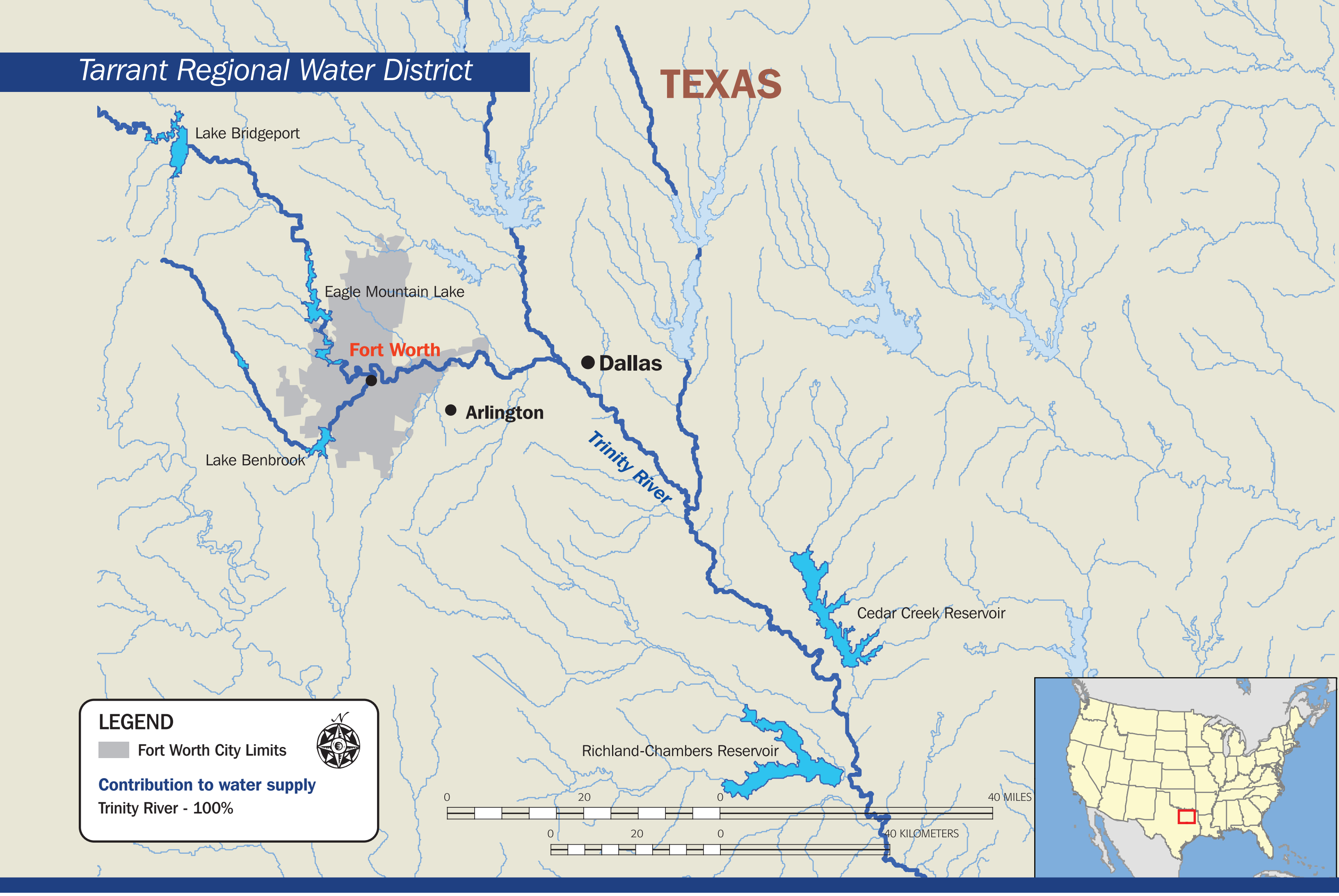
Current Credit Rating

Standard & Poor's		
Rating	**Outlook**	**Rating Date**
AAA	Stable	11/6/2008

Fitch		
Rating	**Outlook**	**Rating Date**
—	—	—

Moody's		
Rating	**Outlook**	**Rating Date**
Aa2	—	5/1/2010

* Junior Lien Obligations Only



Tarrant

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
1,419

Stress Scenarios:

Supply Reduction - High (30%, 3 yrs)
1,515 | 6.76% | 60.25%
Supply Reduction - Low (10%, 3 yrs)
1,525 | 7.51% | 15.59%
Storage Reduction (50%, 5 yrs)
1,495 | 5.35% | 26.91%
Supply Reduction - High + Storage Reduction
1,609 | 13.40% | 46.86%

% = Average increase to risk score across 20-year period

% = Average impact of stress scenario on years affected

TARRANT COUNTY, TEXAS

POPULATION SERVED

The Tarrant Regional Water District is the primary source of water for 40 municipalities and political districts in northeast Texas, including Fort Worth. More than 1.8 million people rely on the Tarrant water system. Major water users include the electric power provider Brazos Electric Power Cooperative.

WATER SUPPLIES

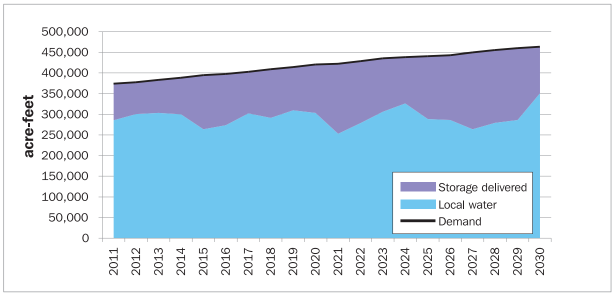
The Tarrant water system relies exclusively on surface water. The Trinity River supplies water to three of its five reservoirs, while the majority of supply comes from the Cedar Creek Reservoir and Richland-Chambers Reservoir southeast of the county. Tarrant estimates its combined 744,333 acre-feet a year to be sufficient through 2016, though it does not consistently report the dependable yield of its supplies.

Tarrant is aggressively pursuing additional supply, including purchased water from Oklahoma's Red River—an idea that faces stiff opposition from the Oklahoma Legislature. The system's lawsuit against the Oklahoma Water Resources Board has been remanded to the U.S. Court of Appeals.

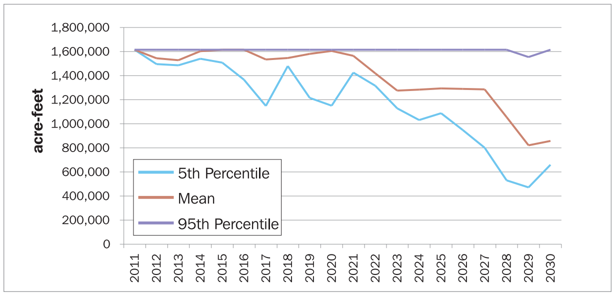
The system is estimated to lose about 10 percent of its water through leakage.

Baseline Scenario: Tarrant

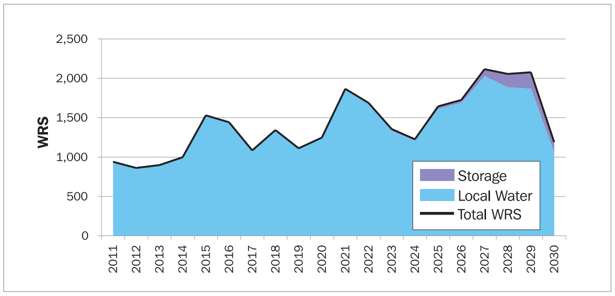
Average annual water delivered by source



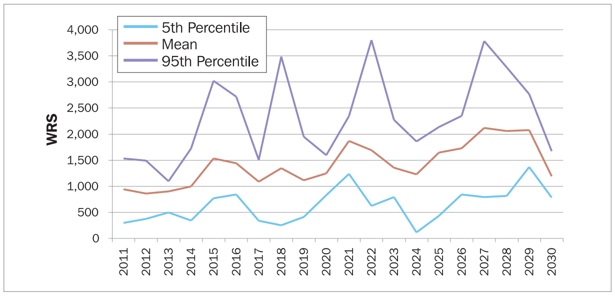
Total storage remaining at the 5th percentile, mean and 95th percentile



Average annual water risk score (WRS)



Total WRS at the 5th percentile, mean and 95th percentile



KEY RISKS

Tarrant's risk score—roughly double that of Dallas—is driven by higher reliance on storage to meet consumer demand.

Tarrant's projected minimum storage withdrawals of 100,000 acre-feet per year make the system vulnerable to persistent drought, which places greater strain on storage reservoirs. Under the baseline scenario, storage drops precipitously starting in 2020, the result of years of drawdown *(see Baseline Scenario: Total storage remaining at the 5th percentile, mean and 95th percentile).*

Given the system's relative vulnerability to drought, management's current practice of planning for dry conditions based on a 14-year historic period may need to be strengthened to decrease its vulnerability to more severe events.

To sustain current levels of consumption, Tarrant is leading the legal charge to permit interstate water transfers from Oklahoma. While winning the right to import water would boost the system's water budget, the gain would come at significant cost—Tarrant is projected to spend $441,548,000 in construction to secure 50,000 acre-feet per year, in addition to annual costs for each acre-foot.[1] Along with increasing the system's debt service costs and operating expenditures, the deal would also move the system toward import dependency, which would further elevate its risk score.

Relatively weak financial ratios may also push the balance to low-capital solutions for managing undersupply. For Tarrant County, the utility with the lowest projected annual debt service coverage ratio in the study, financing an import system would likely require significant rate increases. Yet if structured correctly, similar rate increases could encourage conservation, reducing the need for additional costly supplies.

Even with per capita consumption rates about 30 percent lower than Dallas,[2] Tarrant has significant opportunity to reduce its risk of undersupply through demand-side management. Aggressive conservation goals are critical to avoiding high-cost supply projects.

1 Initially Prepared 2011 Region C Water Plan, Texas Senate Bill 1 Regional Water Planning for Region C (North Texas), March 2010, available at http://www.fortworthgov.org/uploadedFiles/Water/ConservPlan0405(1).pdf.

2 Based on comparison of self-reported water sales and service territory populations.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$16.00	28
Sewer	$17.70	22
Combined	$33.70	30

Pricing Structure: Increasing Block

Projected Annual Debt Service Coverage

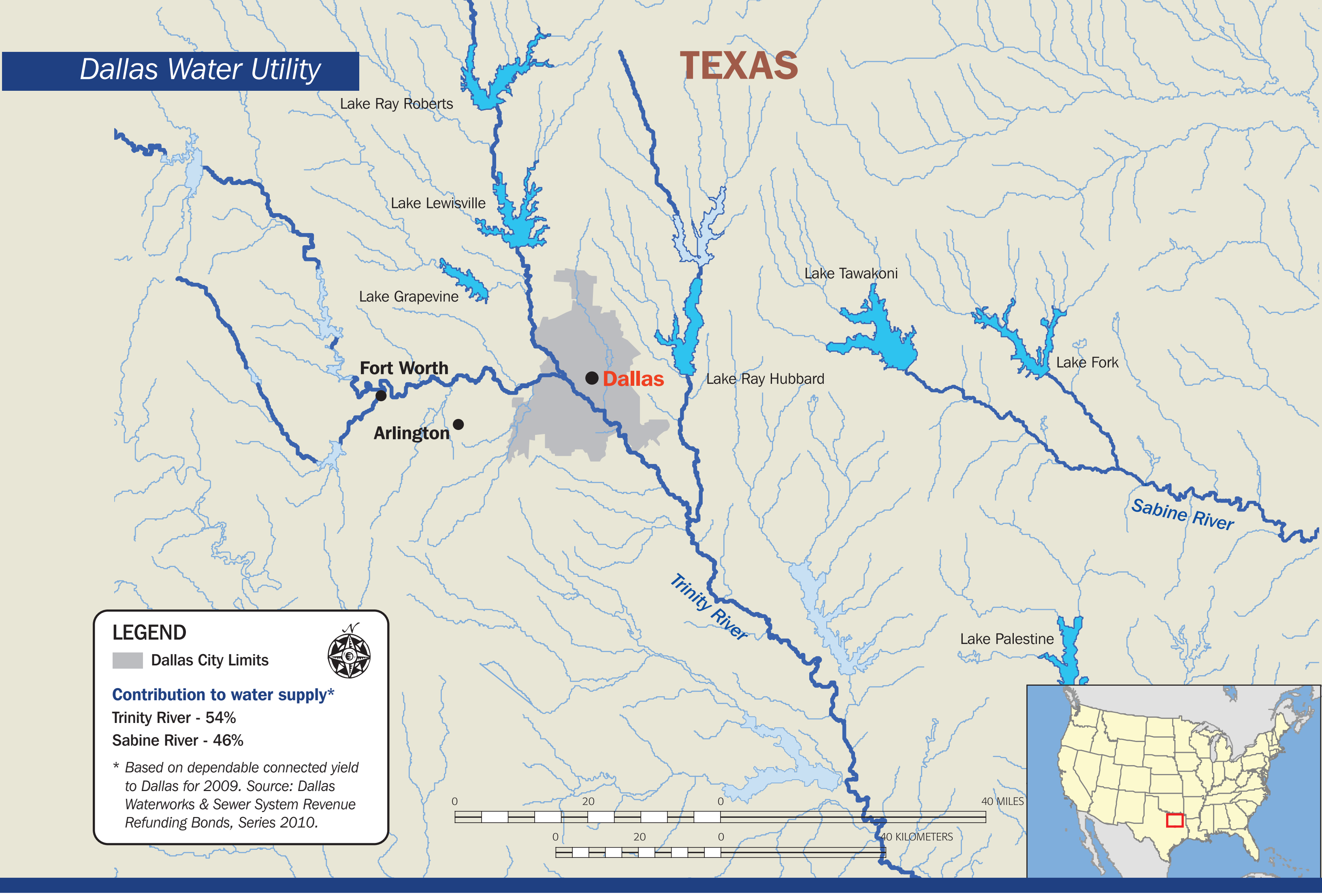
2014 Debt Service Coverage Ratio:

0.92

Current Credit Rating

Standard & Poor's		
Rating	**Outlook**	**Rating Date**
AAA	Stable	2/21/2008
Fitch		
Rating	**Outlook**	**Rating Date**
AA+	Stable	4/30/2010
Moody's		
Rating	**Outlook**	**Rating Date**
Aa1	—	5/7/2010

Dallas Water Utility



Dallas

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
736
Stress Scenarios:
Supply Reduction - High (30%, 3 yrs)
811 | 10.11% | 100.20%
Supply Reduction - Low (10%, 3 yrs)
804 | 9.19% | 19.23%
Storage Reduction (50%, 5 yrs)
800 | 8.65% | 46.09%
Supply Reduction - High + Storage Reduction
874 | 18.69% | 68.82%

% = Average increase to risk score across 20-year period

% = Average impact of stress scenario on years affected

DALLAS, TEXAS

POPULATION SERVED

The City of Dallas, Texas Waterworks and Sewer System delivers water to more than 2.5 million people in around two-dozen cities. Major industrial users include Texas Instruments and UT Southwestern Medical Center.

WATER SUPPLIES

The Dallas water system relies exclusively on surface water. Its primary water source, the Trinity River, supplies water to four of its six active reservoirs. The city holds water rights to a 7th reservoir on the Upper Neches River, Lake Palestine, expected to go online in 2015. While Dallas has rights to 1.8 million acre-feet per year, its dependable yield is closer to 700,000 acre-feet per year.

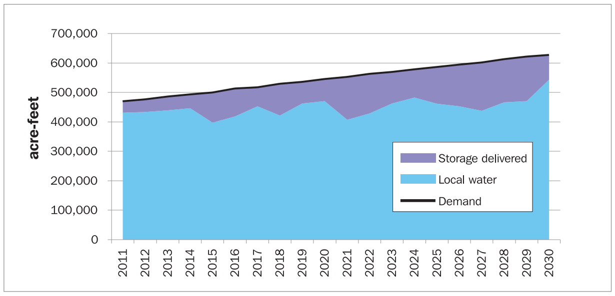
The system is estimated to lose about 10 percent of its water through leakage.

KEY RISKS

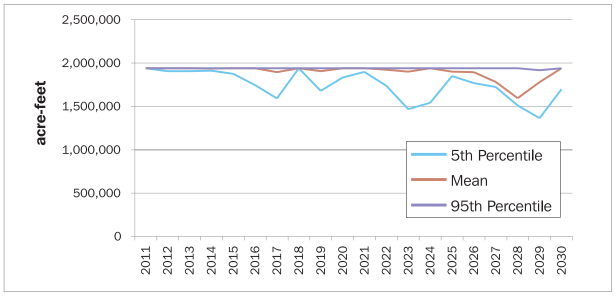
Dallas receives the lowest risk score among all utilities evaluated, due to significant water rights to local river flows and several million acre-feet in storage throughout northern Texas. The system's risk score is a function of its reliance on storage drawdown to meet water demand in all years *(see Baseline Scenario, Average annual water delivered by source)*. While the system's significant storage rights buffer it from undersupply risk, there is significant uncertainty in the extent of storage drawdown the system may experience in any given year—for example, in 2018 the system may see no risk at all (as represented by a risk score of 0) or very high risk (as represented by a risk score close to 2,500) *(see Baseline Scenario, Total WRS at the 5th percentile, average and 95th percentile level)*.

Baseline Scenario: Dallas

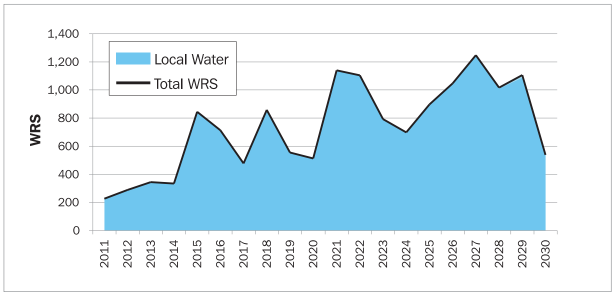
Average annual water delivered by source



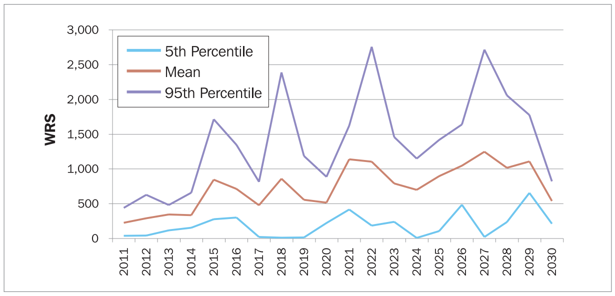
Total storage remaining at the 5th percentile, mean and 95th percentile



Average annual water risk score (WRS)



Total WRS at the 5th percentile, mean and 95th percentile



While the high supply stress scenario—a 30 percent reduction in Dallas' largest source over three years—increases the 20-year risk score by only 10 percent, it more than doubles the risk to storage supplies during the years it strikes (*see Average Water Risk Scores – Baseline & Stress Scenarios, 2011-2030*).

Today Dallas' storage reservoirs are managed to the drought of record—a single event in a 50-year window—making the system vulnerable to more severe shortages driven by long-term climate variability.

Population in the service area is expected to grow to nearly three million by 2030. If water consumption rates hold, that growth may strain the supply of the city's existing reservoirs.

With some of the highest per capita usage rates in the state, Dallas is aggressively pursuing additional supply.

The system has joined Tarrant Regional Water District in a lawsuit against the Oklahoma Water Resources Board to allow interstate water sales to feed north Texas growth. A favorable court decision could move the region toward import dependency, the main risk driver of many of the utilities receiving higher risks scores. Securing imported supplies would also amplify the system's capital and operating budgets—conveying 28,750 acre-feet per year of Red River supplies would demand upfront construction costs of $189,011,000 in addition to ongoing purchase costs.[1]

With relatively high debt capacity, Dallas has the financial flexibility to pursue capital supply expansion projects. Yet with the 8th lowest water rates among large U.S. cities, Dallas has the potential to spur significant conservation gains through pricing, potentially obviating the need to assume further debt for supply projects.

Dallas' long-term water conservation goals are modest compared to supply augmentation targets—around 47 MGD by 2060 compared to nearly 500 MGD in added supply by 2040.[2]

With strong financials, ample storage, and competitive water rights, the largest challenge to Dallas may be building the political will to achieve conservation gains that can offset the need for financing supply expansion.

Water Rate Benchmark

For residential customers with 3,750 gallons of billable water usage (ranked from lowest to highest)

	Cost	Rank
Water	$9.53	8
Sewer	$19.20	28
Combined	$28.73	15

Pricing Structure: Increasing Block

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.50

Current Credit Rating

Standard & Poor's		
Rating	Outlook	Rating Date
AAA	Stable	5/15/2008
Fitch		
Rating	Outlook	Rating Date
—	—	—
Moody's		
Rating	Outlook	Rating Date
Aa1	—	6/7/2010

1 "Initially Prepared 2011 Region C Water Plan," Texas Senate Bill 1 Regional Water Planning for Region C (North Texas), March 2010, http://www.fortworthgov.org/uploadedFiles/Water/ConservPlan0405(1).pdf

2 "City of Dallas Planning and Water Supply Strategies," Presentation given December 6, 2010, http://www.dallascityhall.com/pdf/dwu/WaterPlanningSupplyStrategies.pdf

POWERSOUTH ENERGY COOPERATIVE, ALABAMA

POPULATION SERVED

PowerSouth is a generation and transmission cooperative with 20 distribution members, including 16 electric cooperatives and four municipal systems. PowerSouth serves around one million people in rural Alabama and the Florida panhandle.

KEY FACILITIES

PowerSouth owns and operates six power plants and recently completed a long-term power purchase agreement with the Vogtle nuclear plant on the Savannah River in eastern Georgia. With the exception of an eight MW hydropower facility, PowerSouth's 1700 MW portfolio is primarily comprised of fossil fuel plants. Plant Lowman, a coal-fired plant on the Tombigbee River in western Alabama, is PowerSouth's primary generating facility.

KEY RISKS

PowerSouth faces two key risks:

- Combined water stresses at its primary power source, coal-fired Lowman Plant, including water temperature-related shutdowns and reduced river flows falling lower than the cooling water intake pipe.
- Modest risk from reduced river flows falling below the water demanded by coal-fired Miller Plant.

Unlike many utilities in the Southeast, most of PowerSouth's facilities have recirculating cooling systems. Recirculating systems do not return water to the source, and so are not subject to temperature limits on cooling water. Such limits are expected to necessitate more frequent reductions in power generation at once-through cooled facilities in the Southeast as water temperatures rise with climate change.

PowerSouth

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario

2,548

Stress Scenarios:

High Water Supply Reduction (30%, 3 yrs)
2,550 | 0.04% | 0.32%

Mid Water Supply Reduction (10%, 1 yr)
2,549 | 0.02% | 0.37%

Low Water Supply Reduction (10%, 3 yrs)
2,549 | 0.01% | 0.09%

High Demand
2,559 | 0.40% | 0.40%

Low Demand
2,548 | 0.00% | 0.00%

% = Average increase to risk score across 20-year period
% = Average impact of stress scenario on years affected

PowerSouth Energy Cooperative, Alabama

Lowman Plant

PowerSouth has one 86-MW generating unit cooled by once-through cooling, at the Lowman coal plant. Lowman is PowerSouth's primary generating facility, producing roughly one-third of PowerSouth's generating capacity. The Lowman plant is permitted to release heated cooling water into the Tombigbee River, but the river's temperature cannot be elevated above 90°F—meaning that the plant must reduce power generation on days when the ambient water temperature approaches or exceeds this limit.

Using temperature data provided by the USGS and Alabama Department of Environmental Protection, the model simulated monthly average water temperatures near the cooling water intake point at Plant Lowman. Since daily temperatures will fluctuate around the monthly average, the model applied the following rules to estimate the number of days the plant would need to reduce generation based on the average monthly temperature. (see **Table 1**)

Table 1: Modeled Impacts of Temperature on Supply

Temperature (°F)	Reduction in Supply
< 82	0%
82 – 84	20%
84 – 86	40%
86 – 88	60%
88 – 90	80%
> 90	100%

Water levels in the Tombigbee River relative to the depth of Lowman's water intake structure for all three generating units were also simulated. In two years, lower flows in the river caused water levels to drop below the estimated top of the intake structure, reducing the amount of water delivered by 10 percent. A 10 percent reduction in cooling water may result in a proportionate decrease in power generated. This can be managed in a number of ways, including emergency replacement power agreements (which can be costly), arrangements with large power purchasers to reduce demand during peak hours or annual demand reduction targets that can be met through energy efficiency programs. A water shortage of more than 10 percent may necessitate more costly interventions.[1]

Other Facilities

PowerSouth has an 8.16 percent ownership stake in Plant Miller, a coal-fired power plant jointly owned with investor-owned Alabama Power. Of Miller's 2,664 MW capacity, PowerSouth has rights to 114 MW. Across the twenty years modeled, Plant Miller experienced reduced water flows of one percent at the highest. Though this contributed modestly to PowerSouth's risk score, it is unlikely that such a marginal reduction in flows would result in material reductions in power generation.

As with modeling output for Plant Lowman, the uneven quality of information on the cooling water intake structures at PowerSouth's facilities may result in over- or under-estimates of the effect of variable water supplies. Improved information may yield significantly different results.

Water flows modeled at all other facilities showed sufficient water supply to support seasonal demand, including at the Vogtle nuclear plant in Georgia. Unlike a number of nuclear generators in the Southeast, Vogtle is cooled using a recirculating system, making it far less vulnerable to drought and heat waves.

Most of PowerSouth's facilities are relatively resilient to the drought and heat waves expected to occur more frequently as the Southeast encounters the effects of manmade climate change. Its high risk score reflects the vulnerability of its most important facility to these stresses.

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

1.20

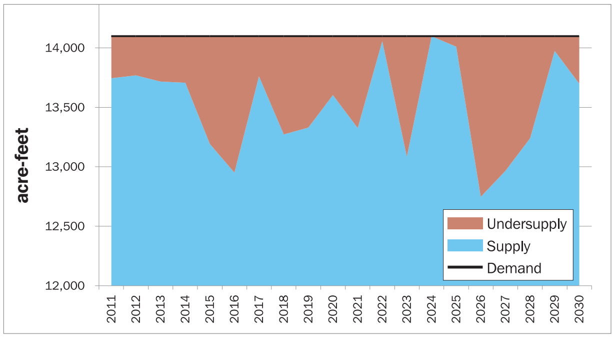
Current Credit Rating

Agency	Rating	Outlook	Rating Date
Standard & Poor's	A-	Stable	9/7/2010
Fitch	A-	Stable	9/16/2010
Moody's	A3	—	9/19/2010

1 Better information on the cooling water intake structure may yield different results on the extent of undersupply caused by lowered river levels. Self-reported intake pipe depth in a survey by the Energy Information Agency was 10 feet below the river surface. The depth value used in the model was 12 feet, based on information provided by one of Lowman's facility managers.

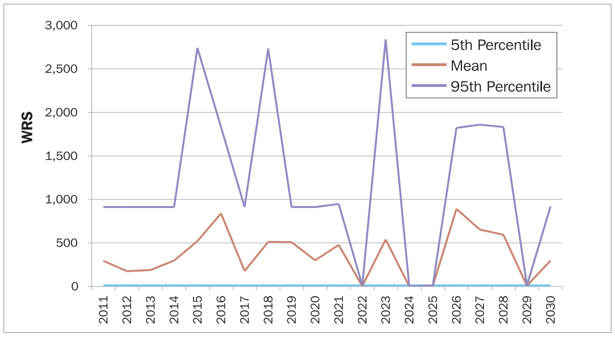
Undersupply at Lowman Plant

Annual volume of water in acre-feet



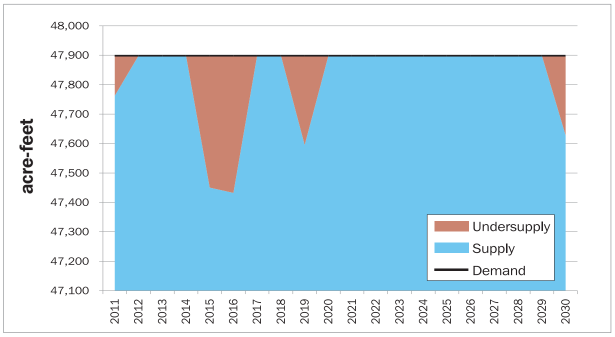
Includes effects of water falling below intake structure and ambient water temperature exceeding 90°F.

Risk Score Contribution - Lowman Plant

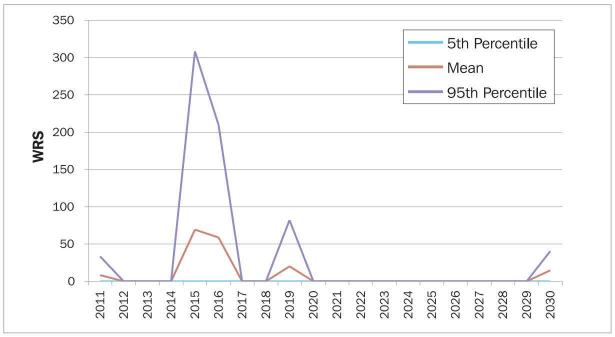


Undersupply at Miller Plant

Annual volume of water in acre-feet

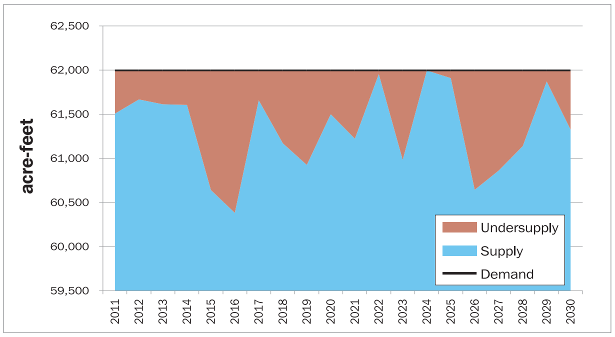


Risk Score Contribution - Miller Plant



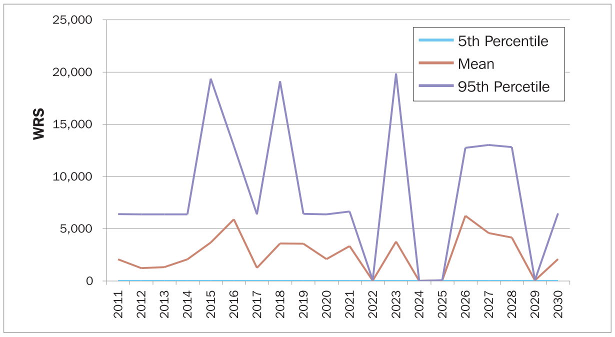
Total Undersupply at All Facilities

Annual volume of water in acre-feet



The horizontal line is water demand averaged across all facilities.

Total Water Risk Score



LADWP

Average Water Risk Scores: Baseline & Stress Scenarios (2011-2030)

Baseline Scenario
1,528
Stress Scenarios:
High Water Supply Reduction (30%, 3 yrs)
1,783 | 16.72% | 204.79%
Mid Water Supply Reduction (10%, 1 yr)
1,618 | 5.92% | 225.60%
Low Water Supply Reduction (10%, 3 yrs)
1,585 | 3.75% | 30.37%
High Demand
2,978 | 94.97% | 94.97%
Low Demand
919 | -39.83% | -39.83%

% = Average increase to risk score across 20-year period

% = Average impact of stress scenario on years affected

LOS ANGELES DEPARTMENT OF WATER AND POWER, POWER REVENUE FUND

POPULATION SERVED

Los Angeles Department of Water and Power (LADWP) serves 4.1 million residents and businesses across 485 square miles, making it one of the largest public power providers in the United States. Los Angeles customers purchased about 24.8 million megawatt-hours during 2009.

KEY FACILITIES

LADWP has a diverse portfolio of natural gas, coal, nuclear, renewable and large hydroelectric facilities, with an estimated net dependable capacity of 7,226 MW. While all of the natural gas facilities and a major hydroelectric installation are in the greater Los Angeles area, at least one-third of the power sold by LADWP is generated well beyond the city's borders, at facilities including a major nuclear plant in Phoenix, Arizona and coal-fired power plants in Utah and Arizona.

In recent years, LADWP has begun phasing out its coal sources in favor of energy efficiency and renewable sources, in compliance with the state's Greenhouse Gas Emissions Performance Standard Act, SB 1368, which limits imports from high-carbon energy sources, and state and energy commission standards requiring LADWP to source at least one-third of its power from renewable energy sources by 2020. As part of this effort, LADWP has committed to ending it purchases with the Navajo Generating Station, a 2,250 MW coal-fired power plant in Arizona, by 2019, and may not renew its purchases from the coal-fired Intermountain Power Project in 2027. Hydroelectric power dominates LADWP's renewable sources, and is generated at a number of small and large facilities, the most recognized of which is Hoover Dam outside of Las Vegas. LADWP purchases a little more than 15 percent of Hoover Dam's production.

Los Angeles Department of Water and Power, Power Revenue Fund

KEY RISKS

LADWP faces three key risks:

- Reduced power deliveries from Hoover Dam.
- Decreased water availability at coal-fired Intermountain Power Project.
- Compliance costs for ocean-cooled facilities.

Hoover Dam

Low flows in the Colorado River may reduce the reliable power deliveries from Hoover Dam. Historically, Hoover has generated between two and 10 million MWh per year. In recent years, lower levels in Lake Mead have resulted in average annual generation of around four million MWh. Simulated levels in Lake Mead between 2011 and 2030 would produce at most 3.5 million MWh, and in some years as little as 2.5 million MWh, resulting in lower than near-term average power delivered to each of the entitled cities and states. Reduced power delivery from Hoover Dam is the largest contributor to LADWP's risk score.

Intermountain Power Project

During the same time period, Los Angeles could see reductions in reliable power delivery from the coal-fired Intermountain Power Project (IPP). Los Angeles purchases a majority share of the generating capacity of the 1,800 MW power plant located southwest of Salt Lake City. The IPP is cooled with water impounded from the Sevier River, a major source of irrigation water for farms in rural Utah. The river drains to Sevier Lake, which now runs dry as the river's water is completely allocated for human use. To run at peak capacity, the IPP requires a little more than 21,500 acre-feet of water each year. In 19 of 20 simulated years, water volume at the intake point for the IPP is less than the volume demanded by the plant to run at 100 percent capacity. In several years, simulated water levels fall 2,500 acre-feet below the amount needed to run the plant at full capacity, which could translate to monthly generation reductions of more than 10 percent.

Navajo Generating Station

LADWP also purchases power from the coal-fired Navajo Generating Station, near Page, Arizona. Cooling water for the Navajo plant is provided by Lake Powell. In 2005 (the fifth year of the now 11-year drought in the Colorado River Basin), the U.S. Department of the Interior approved a request by Navajo to lower the cooling water intake pipe by more than 100 feet, estimating that by the end of 2007, water levels in Lake Powell would drop below the facility's existing pipe.[1] Simulations of future levels in Lake Powell (run only to 2019, when LADWP plans to stop purchasing from Navajo) show the level well above Navajo's new intake pipe, assuming that water deliveries from Lake Powell are consistent with historical deliveries. In the near future, the Bureau of Reclamation, which manages the Colorado River reservoirs, may need to take unprecedented steps to transfer water from Lake Powell to Lake Mead to satisfy California's water rights. If the ongoing drought persists, such management actions could result in levels in Lake Powell lower than those simulated.

Ocean-Cooled Facilities

LADWP has three natural gas facilities cooled by ocean water. In recent years, the state of California has taken actions to enforce upgrades to existing ocean-cooled power plants to limit harmful effects to aquatic organisms taken in with the facility's cooling water. These regulatory actions are important for limiting harm to fisheries that are a significant source of economic value, however they also present significant costs to utilities that must upgrade thermoelectric facilities to compliance levels. To reflect this cost, each of LADWP's once-through, ocean-cooled facilities was assessed a one-time risk score, contributing modestly to LADWP's overall risk score.

Projected Annual Debt Service Coverage

2014 Debt Service Coverage Ratio:

2.47

Current Credit Rating

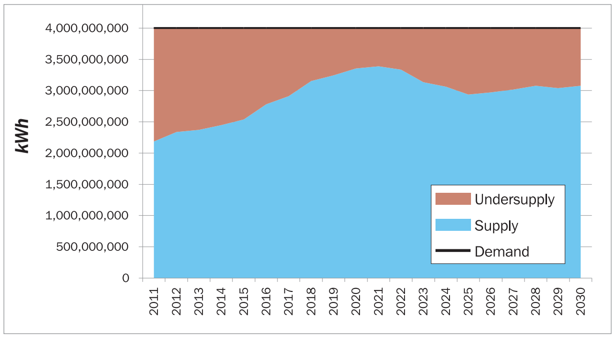
Standard & Poor's		
Rating	Outlook	Rating Date
AA-	Stable	11/19/2008
Fitch		
Rating	Outlook	Rating Date
AA-	Stable	9/8/2010
Moody's		
Rating	Outlook	Rating Date
Aa3	—	8/19/2010

1 "Navajo Generating Station Water Intake Project Environmental Assessment," U.S. Department of the Interior, March 2005.

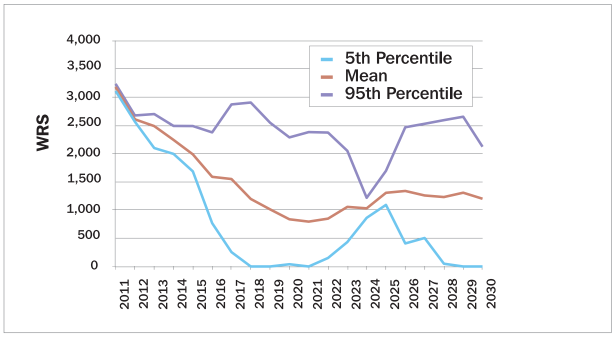
Los Angeles Department of Water and Power, Power Revenue Fund

Undersupply at Hoover Dam

Annual power generated in kWh

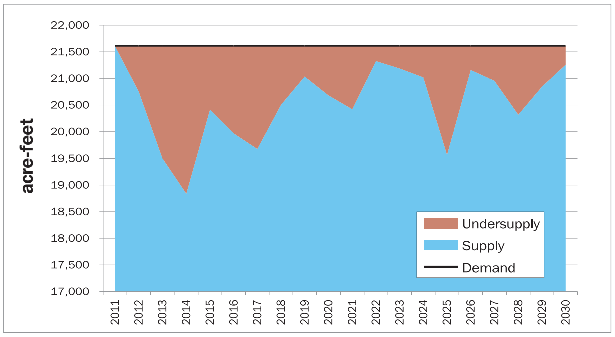


Water Risk Score Contribution - Hoover Dam

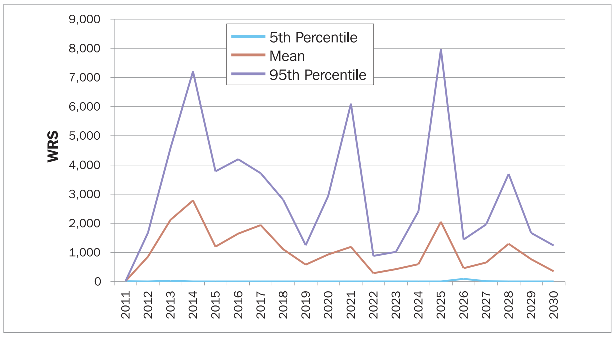


Undersupply at Intermountain Power Project

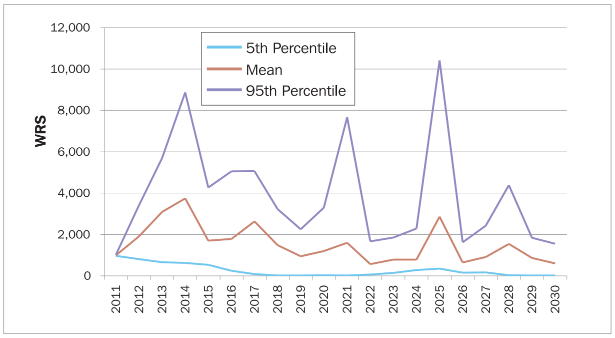
Annual volume of water in acre-feet



Risk Score Contribution - Intermountain Power Agency



LADWP - Total Water Risk Score



To build a reliable clean energy portfolio, LADWP must consider its exposure to water risk from all generation sources. For example, LADWP is considering ways to bring its coal resources into compliance with SB 1368. Yet technologies to reduce the greenhouse gas emissions from coal-fired power plants may double their water consumption, further impairing the reliability of LADWP's supply.

LADWP is also currently formulating plans to manage the variability of renewable power resources. Such a plan should consider the potential for increased variability in its current supplies, including reduced dependable capacity from Hoover Dam, which the system relies upon to meet peak power demand, and potential water-related power reductions at IPP, which provides part of the system's base load.

Finally, although LADWP has taken significant steps to reduce consumer demand for electricity, the utility can do more to manage supply volatility through demand-side management including energy efficiency.

RECOMMENDATIONS FOR UTILITIES, UNDERWRITERS, INVESTORS AND RATING AGENCIES

As population growth, increased water and power demand, and climate change stress water sources across the country, investors will need to manage their exposure to these risks. Screening out issuers based on geography alone may be insufficient to shield a portfolio from water risk in the utility sector, and may limit exposure to utilities with sound management practices. The use of improved information on utilities' exposure and sensitivity to water stress in credit ratings and security selection will be necessary to protect investors from water stress and to drive improved management of scarce resources.

Utilities, underwriters, credit raters, and buyers all play a role in ensuring the liquidity of the utility debt market. This section outlines actions that should be taken by each of these actors to manage and reduce water risk.

Recommendations for Utilities, Underwriters, Investors and Rating Agencies

Water Utilities

- **Improve disclosure of water stress in financial documents.** Utilities should disclose all material water stresses including supply contamination, persistent drought or long-term climatic shifts causing wetter or drier conditions, interstate legal conflicts over shared resources, and potential and existing legal actions related to environmental flows.

  Useful disclosures would offer an assessment of the utility's sensitivity to these stresses, including likely reductions in delivery based on junior or senior water rights, potential capital costs, rate adjustments, and revenue effects. Utility disclosures should incorporate exposures in the utility's own supply sources, as well as in water purchase agreements.

- **Invest in measures to reduce risk.** Sound water disclosure would also describe measures the utility is taking to mitigate risk, such as:

  Implementing strategies to manage demand and reduce leakage. As capital costs rise and water flows become more variable, utilities should:

  - Consider full-cost pricing strategies to reflect water scarcity and multi-tiered water pricing that rewards conservation.
  - Employ conservation strategies designed to reduce per capita consumption, such as rebates for water-efficient appliances, residential and commercial water audits, and incentives to replace turf with less water-intensive landscaping.[1]
  - Develop rigorous programs for monitoring and addressing leakage from pipes, which can amount to 10-30 percent of treated, potable supply in many U.S. cities.

- **Invest in "closed loop" alternative supplies, including indirect potable reuse.** For decades, water supplies have been used in an open loop system: utilities deliver freshwater supplies to customers while discharging treated wastewater downstream. As both local and imported freshwater supplies become more volatile, utilities will need to redefine local water supplies to include reclaimed wastewater.

Managing Alternative Supply Infrastructure Costs

While integrating reclaimed wastewater into local supplies will pose new infrastructure costs for treatment and conveyance, in some regions the costs may be far less significant than those associated with bringing on new freshwater supplies, which can range into the billions for construction costs alone. Reclaimed wastewater may also reduce a utility's exposure to legal actions to protect threatened species in key watersheds or to water supply conflicts with competing users.

- **Invest in green infrastructure to protect and restore natural hydrological systems.** Utilities challenged by frequent flooding events or increased water competition can reduce the strain on traditional or "gray" infrastructure by protecting or restoring natural hydrological systems—an approach known as green infrastructure. Green infrastructure investment includes a range of practices including:

  - Preserving natural wetlands and watersheds that conserve water resources at their source;
  - Designing green spaces that provide natural drainage and habitat for native species; and
  - Updating urban infrastructure through porous pavement and sidewalks that recharge aquifers and reduce run-off.

1 For additional information on effective strategies for managing water demand, see the Alliance for Water Efficiency's Resource Library, http://www.allianceforwaterefficiency.org/

Managing Green Infrastructure Costs

Green infrastructure provides many services in addition to preserving freshwater sources, such as habitat protection, recreation, and water filtration. These diverse benefits may allow utilities to share project costs with other public and private groups, including environmental organizations—a significant advantage over "gray" infrastructure wholly-owned and maintained by the utility itself.

Green infrastructure also can reduce utilities' vulnerability to legal risks, as functioning ecosystems protect water quality and provide habitat for threatened species.

All of these practices are aimed at naturally managing stormwater, reducing flooding risk, allowing for aquifer recharge, and ultimately improving water quality.

Green infrastructure approaches are relevant even in arid regions where approaches such as rainwater harvesting, natural water capture, and aquifer recharge can be a cost-effective means for managing and augmenting supply.

Electric Utilities

- **Improve water stress disclosure in financial documents.** Utilities should provide information on all material water stresses caused by increased competition for water resources, emerging regulation, and changing climatic conditions.

  Material information should include details on:
  - Water intensity of generation
  - Water sources and cooling systems for thermoelectric facilities
  - Water rights of major facilities
  - Any water-related shutdowns or reductions in generation
  - Proposed regulations that would require retrofitting of cooling systems

  Useful disclosures would offer an assessment of the utility's sensitivity to these stresses, including potential capital costs, rate adjustments, and revenue effects.

  Utility disclosures should incorporate exposures in wholly- and jointly-owned facilities, as well as in power purchase agreements.

- **Invest in measures to reduce risk.** Sound water disclosure would also describe measures the utility is taking to mitigate risk, such as:

  Implementing strategies to reduce energy—and therefore water—demand. Against a backdrop of rising capital costs, intensified competition for water resources, and more stringent environmental regulations requiring costly investment in low-water cooling systems, utilities that continue to overwhelmingly pursue generation expansion to meet customer energy needs rather than investing in less expensive demand-side management strategies are more likely to experience liquidity problems.

Utilities aggressively pursuing energy efficiency to reduce customer electricity demand are more likely to maintain strong financial ratios by limiting the need for capital expenditures.[2] Energy efficiency portfolios typically save electricity at a cost of about $0.03 per kWh, which is roughly two to three times less expensive than many supply-side resources. Supportive regulation and financial incentives are required to make energy efficiency a viable resource option for electric utilities.

Rebalancing generation portfolios toward low-water intensity, clean energy. Water-intensive and carbon-intensive generation assets are a growing liability for electric utilities. To offset associated regulatory and physical risks, utilities should integrate cost-effective, low-water intensity renewable energy into their asset base.[3]

Investing in cost-effective alternative water supplies, including reclaimed water. As competition for water supplies intensifies, electric utilities with water-intensive portfolios may need to invest in alternative water supplies less likely to be challenged by water stress, such as reclaimed wastewater. Electric utilities should pursue opportunities to co-locate new generation assets with wastewater treatment plants or other sources of reclaimed water.

Bond Underwriters

- **Assist utilities in disclosing their sensitivity to water stress and plans for mitigating their risk.** Bond underwriters have a duty to assist issuers in disclosing all material risks in official statements and reports to investors following material events. To fulfill this duty, underwriters have the obligation to ensure that issuers adequately disclose material water risks and water-related events—including legal rulings and regulatory actions—that may materially impair a utility's revenue stream or impose significant capital costs. As investors seek better information on utilities' water risk exposure and sensitivity, underwriters should assist issuers in crafting meaningful disclosures that help investors understand an issuer's capacity for managing risks.
- **Help to secure competitive cost of capital for utilities managing water risk.** All things being equal, issuers pursuing demand-side management or more secure alternative supplies should pose less risk to investors, and should benefit from lower cost of capital. Underwriters should help issuers that are actively managing risk exposure to secure competitive interest rates.

Rating Agencies

- **Test utility sensitivity to water stress.** While some utilities are factoring forward-looking water trends into capital planning, rate-making, and revenue projections, many continue to assume the future will look like the past. Rating agencies should employ stress tests to understand the sensitivity of an issuer to stresses such as legal rulings over contested sources, restrictions for environmental flows or changing climatic conditions. Such stress tests would be helpful in comparing the risk of adjacent utilities, and assist investors in understanding comparative risks.

2 For a more detailed framework of demand-side management strategies, see *The 21st Century Utility: Positioning for a Low-Carbon Future*, Ceres, July 2010.

3 For a more detailed analysis of the levelized cost of renewable energy resources, see *The 21st Century Utility: Positioning for a Low-Carbon Future*, Ceres, July 2010.

- **Factor water intensity into rating opinions for electric utilities.** Utilities heavily weighted with water-intensive assets may incur significant capital costs and experience contingencies more regularly in the future than in the past. Rating agencies can help investors understand this evolving risk by incorporating factors such as utilities' water intensity, incidence of water-related shutdowns, and vulnerability of cooling systems to physical and regulatory risks into rating opinions. Rating agencies can also assist investors in understanding comparative risks by benchmarking utilities on water use for thermoelectric power generation.
- **Reward utilities for managing demand.** The increasing marginal cost of additional water and power supplies can undermine utility liquidity. Yet utilities pursuing aggressive demand-side management through rate-making may be penalized if rating agencies consider their rates to be higher than regional benchmarks. Utilities that manage demand through pricing in anticipation of future supply constraints should be viewed as exercising good management practices—and should be rated accordingly.

Investors

- **Engage large utilities on their sensitivity to water stress.** The information currently provided by rating agencies and issuers may be insufficient to measure a utility's sensitivity to water risk. Institutional investors can engage municipal utilities one-on-one or through organized surveys similar to the Carbon Disclosure Project's water survey, which surveys investor-owned corporations, including utilities.
- **Ask asset managers to assess and engage utilities on water risks.** Institutional investors should incorporate water risk into asset manager requests for proposals and annual performance reviews to ensure that they manage exposure to water risk in municipal debt portfolios.
- **Request guidance from financial regulators on municipal disclosure of water and climate risks.** Municipal issuers are not subject to the Securities and Exchange Commission's (SEC) 2010 interpretive guidance, which directs corporate issuers to disclose material information related to the physical effects of climate change, including the availability and quality of water.[4] To ensure sector-wide disclosure of water risks to public utilities, investors should engage the Municipal Securities Rulemaking Board and the SEC to provide guidance to issuers and underwriters regarding disclosure of material water and climate risks.

4 Securities and Exchange Commission, 17 CFR PARTS 211, 231 and 241 [Release Nos. 33-9106; 34-61469; FR-82], *Commission Guidance Regarding Disclosure Related to Climate Change*, February 2, 2010. See www.sec.gov/rules/interp/2010/33-9106.pdf

APPENDIX

WATER USE FOR THERMOELECTRIC POWER GENERATION

Electric power plants account for 41 percent of freshwater withdrawals in the United States.[1] In fact, Americans require nearly three times as much water to generate electricity as they use for domestic water needs.

The water intensity of a kilowatt-hour depends on two key factors:

- the type of ***generation or fuel source*** that produced the energy, and
- the ***cooling technology*** employed at the facility.

Each type of generation source has its own water intensity, meaning the volume of water required per kilowatt-hour of energy produced. Depending on the generation source, the water is either *withdrawn* and returned to the source or *consumed*, usually through steam production.

Water intensity of fuel sources varies significantly. Nuclear power generation generally consumes about 25 percent more water per kilowatt-hour than coal, through steam exhausted for cooling. See **Table 1** for relative water intensities of coal, natural gas, and nuclear sources.

The water intensities of two plants of the same generation capacity and fuel source can differ by as much as 100 percent given the cooling technology employed. Around 50 percent of the nation's thermoelectric power plants employ the most water-intensive cooling technology, known as once-through cooling.[2] Once-through cooling is the largest driver of water demand for a typical thermoelectric plant, requiring up to 500 gallons per minute of MW generated.[3] See **Exhibit 1** for a description of cooling systems.

Finally, many coal-fired plants rely on water to control particulates such as sulfur dioxide in their air emissions. Wet flue gas desulfurization (FGD) can nearly double the water consumption per kilowatt hour. See **Table 1** for relative water intensities of coal plants with and without FGD.

1 USGS, 2009.

2 U.S. Energy Information Administration, "EIA-767 Data Files: Annual Steam-Electric Plant Operation and Design Data," 2005, see 2005 data especially F767_COOLING_SYSTEM.xls available at http://www.eia.doe.gov/cneaf/electricity/page/eia767.html

3 Electric Power Research Institute, "Comparison of Alternate Cooling Technologies for California Power Plants: Economic, Environmental and Other Tradeoffs," February 2002

Water Use for Thermoelectric Power Generation

Table 1: National Average Water Withdrawal and Consumption Factors for Model Power Plants

Coal Plants

Model Plant	Withdrawal Factor (gal/kWh)	Consumption Factor (gal/kWh)
Freshwater, Once-Through, Subcritical, Wet FGD	27.113	0.138
Freshwater, Once-Through, Subcritical, Dry FGD	27.088	0.113
Freshwater, Once-Through, Subcritical, No FGD	27.046	0.071
Freshwater, Once-Through, Supercritical, Wet FGD	22.611	0.124
Freshwater, Once-Through, Supercritical, Dry FGD	22.59	0.103
Freshwater, Once-Through, Supercritical, No FGD	22.551	0.064
Freshwater, Recirculating, Subcritical, Wet FGD	0.531	0.462
Freshwater, Recirculating, Subcritical, Dry FGD	0.506	0.437
Freshwater, Recirculating, Subcritical, No FGD	0.463	0.394
Freshwater, Recirculating, Supercritical, Wet FGD	0.669	0.518
Freshwater, Recirculating, Supercritical, Dry FGD	0.648	0.496
Freshwater, Recirculating, Supercritical, No FGD	0.609	0.458
Freshwater, Cooling Pond, Subcritical, Wet FGD	17.927	0.804
Freshwater, Cooling Pond, Subcritical, Dry FGD	17.902	0.779
Freshwater, Cooling Pond, Subcritical, No FGD	17.859	0.737
Freshwater, Cooling Pond, Supercritical, Wet FGD	15.057	0.064
Freshwater, Cooling Pond, Supercritical, Dry FGD	15.035	0.042
Freshwater, Cooling Pond, Supercritical, No FGD	14.996	0.004

Nuclear Plants

Model Plant	Withdrawal Factor (gal/kWh)	Consumption Factor (gal/kWh)
Freshwater, Once-Through	31.497	0.137
Freshwater, Recirculating	1.10	0.624

Fossil Non-Coal

Model Plant	Withdrawal Factor (gal/kWh)	Consumption Factor (gal/kWh)
Freshwater, Once-Through	22.74	0.09
Freshwater, Recirculating	0.25	0.16
Freshwater, Cooling Pond	7.89	0.11

IGCC/NGCC Plants

Model Plant	Withdrawal Factor (gal/kWh)	Consumption Factor (gal/kWh)
NGCC, Freshwater, Once-Through	9.01	0.02
NGCC, Freshwater, Recirculating	0.15	0.13
NGCC, Freshwater, Cooling Pond	5.95	0.24
NGCC Air-Cooled	0.004	0.004
IGCC, Freshwater, Recirculating	0.22	0.173

Source: National Energy Technology Laboratory, "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements," September 30, 2008.

Water Use for Thermoelectric Power Generation

Exhibit 1: Thermoelectric Cooling Technologies

Once-Through Systems

Water is withdrawn from the environment, passed through a steam condenser and returned, slightly heated (typically by 20-25°F), to the source. Withdrawal rates are typically in the range of 500 gallons per minute per MW generated. No water is consumed or evaporated within the cooling system, but the evaporation rate from the receiving water is slightly higher in the vicinity of the discharge plume, where the used cooling water is returned to the environment.

Recirculating Wet Systems

In recirculating wet systems, water withdrawn from a local source is circulated continuously through the cooling system. Recirculating systems require only two to three percent of the withdrawals of once-through systems. However, far more water is consumed through evaporation in the cooling towers, with very little water returned to the source.

Dry Systems

In dry systems, equipment is cooled by discharging heat directly to the atmosphere. Dry systems reduce water use at a plant by eliminating the use of water for steam condensation. Depending on the type of dry cooling employed, little to no water is used. But dry cooling requires significant energy use, and can substantially decrease the facility's power delivery to the grid.

Hybrid Wet-Dry Systems

In hybrid wet-dry systems, both wet and dry components are included in the system, and they can be used separately or simultaneously to conserve water or avoid thermal discharges to the water source. Depending on system design, water consumption can be from two to 70 percent of water consumption rates for wet recirculating systems.

Source: Adapted from Electric Power Research Institute, "Comparison of Alternate Cooling Technologies for California Power Plants: Economic, Environmental and Other Tradeoffs," Report for California Energy Commission, February 2002.

Water stress on electric power may reduce generation capacity in a number of ways:

- **Water scarcity may compromise the volume of water available for cooling.** An electric utility's water footprint depends on its generation mix and cooling technology. Reduced water flows may undermine a utility's ability to get the volume of water needed to run its facilities to meet electric power demand or to maintain grid base load.
- **Water level drops below cooling intake structure.** Power plant cooling intake structures are at a fixed height. If water levels decrease, the plant may be able to access only a portion of the water available in the system, and be forced to reduce its generation capacity to as little as 65-75 percent. For baseload plants, such a reduction in generation capacity may imperil the entire grid.[4] If this happens frequently enough, the intake structure may need to be reconfigured, a complex and expensive task, as pipes are usually made of concrete, can be up to 18 feet in diameter and can extend up to a mile.[5] The cost of retrofitting an intake pipe can be as much $200 million for a baseload coal or nuclear plant and require an extensive environmental permitting process.[6]

4 Michael Hightower, interview with author, July 1, 2010.
5 Weiss, 2008.
6 Hightower, 2010.

Water Use for Thermoelectric Power Generation

- Increased water temperature may reduce cooling efficiency or exceed environmental permit conditions, forcing reduction in generation. Wet thermoelectric cooling relies on the difference in temperature between the ambient atmosphere and the water source. Typically plants are allowed to discharge used coolant water about 15-20°F above intake water temperature, which is usually quoted at a seasonal average. If the summer average is set at 75°F, the water temperature after the discharge point may not be permitted to exceed 90°F. Under such a permitting restriction, a five degree increase in pre-intake water temperature can reduce operating capacity by as much as half. A long heat wave may reasonably reduce capacity to 50-75 percent.

It is important to note that any of these stresses may occur simultaneously, creating a geometric reduction in capacity.

Constructing an accurate picture of a utility's exposure to these risks requires facility-specific information. For example, simply knowing the location of a power plant is not sufficient to understand its susceptibility to drought. Of the five coal-fired power plants sited on the Delaware River, water intake pipe depths vary from six to 15 feet.[7] In a drought situation, that variable alone may idle one plant, while the others continue to generate at full capacity (see **Table 2** for more information on the variability of intake depths of traditional generation sources).

Table 2: Variability of Intake Depth from Surface for 423 Power Plants

Power Plant Category	Median Depth (ft)	Standard Deviation (ft)
All	12	16.7
Coal and Oil	12	19.1
Gas	12	9.0
Nuclear	13.5	15.5
Rivers and Creeks (cooling source)	10	9.9
Lakes and Reservoirs (cooling source)	17	25.2

Source: Adapted from Table 2, National Energy Technology Laboratory, 2008

7 National Energy Technology Laboratory, 2008.

KEY WATER STATUTES

The **Clean Water Act** (CWA) empowers the EPA to regulate discharges of pollutants into surface waters. Water utilities and electric utilities are both subject to CWA standards. Effluent from wastewater treatment plants and thermoelectric facilities must be in compliance with standards set under the National Pollutant Discharge Elimination System (NPDES). NPDES pollutants include thermal effluent from power plants, regulated under Section 316(a). Power plants are also regulated under Section 316(b), which sets standards for cooling intake structures to minimize environmental impact. State water quality standards must treat the CWA as a minimum.

The **Safe Drinking Water Act** (SDWA) allows the EPA to set standards protecting the quality of drinking water in the United States, including surface water and groundwater. Under the SDWA, EPA establishes minimum health-based standards for drinking water, with which all public water systems must comply.

From time to time, the EPA has revised the permissible concentrations of pollutants in response to emerging scientific data on the exposure effects for humans and ecosystems or in response to lawsuits claiming inadequate protection of human or ecosystem health. Such revisions can present significant compliance costs for utilities (see **Exhibit 1**).

The **Endangered Species Act** (ESA) empowers the Secretary of the Interior[8] to list a species as either endangered or threatened based on a number of factors, including:

- present or threatened destruction of a species habitat or range,
- its overuse for commercial, recreational, scientific, or educational purposes,
- disease or predation,
- inadequate existing regulatory mechanisms for its protection.[9]

8 Or the Secretary of Commerce, or the Secretary of Agriculture; see Endangered Species Act of 1973(16 U. S. C. §1532), Definitions, Section 3(14)
9 See Endangered Species Act of 1973 (16 U. S. C. § 1532), Section 4(1)

Exhibit 1: Significant Water Quality Rulemaking

Safe Drinking Water Act

On March 29, 2010, EPA published a notice in the Federal Register seeking comment on its review of the 71 existing National Primary Drinking Water Regulations (NPDWRs) and the Agency's conclusion that four regulated contaminants—acrylamide, epichlorohydrin, tetrachloroethylene, and trichloroethylene—are candidates for regulatory revision. It is expected that as exposure studies and water technologies evolve, the EPA will continue to review and potentially revise water quality standards in ways that may pose new compliance costs for water suppliers.

Clean Water Act

Section 316(b) allows the EPA to require that the thermoelectric power plants use "the best technology available for minimizing adverse environmental impact." As of 2001, all new thermoelectric plants are required to employ the best available technology to minimize environmental damage to fish and other organisms that may be drawn into the cooling water intake structure, a rulemaking that effectively mandates the use of recirculating wet cooling or dry cooling systems (see Appendix A).[10] The EPA is seeking comments on a cost-benefit study for modifying regulations on cooling water intake structures of existing facilities[11] and is expected to publish a Notice of Proposed Rulemaking for existing power plants in 2010.[12]

10 U.S. Environmental Protection Agency, "Cooling Water Intake Structure," http://cfpub.epa.gov/npdes/indpermitting/cwis.cfm
11 U.S. Environmental Protection Agency, "Cooling Water Intake Structures—CWA §316(b)," http://www.epa.gov/waterscience/316b/
12 Brownstein, 2010.

METHODOLOGY FOR MODELING WATER RISK

This report proposes a quantitative model, developed by PwC, to help investors assess a utility's exposure and sensitivity to water risk. Drawing on public information gathered from federal reports, bond statements and utility planning documents, the framework generates a water risk score that can be used by investors to understand relative risk between bonds and issuers. By coupling the *water risk score* with financial information already available in credit rating opinions and bond documents, investors can gain a more complete picture of a bond's total risk.

The water risk scores were designed to give a sense of the relative risk of undersupply of water over a 20-year period based on the utility's present supply mix as described in bond official statements. The water risk score is **not** an indicator of the likelihood of default.

Securities of Interest

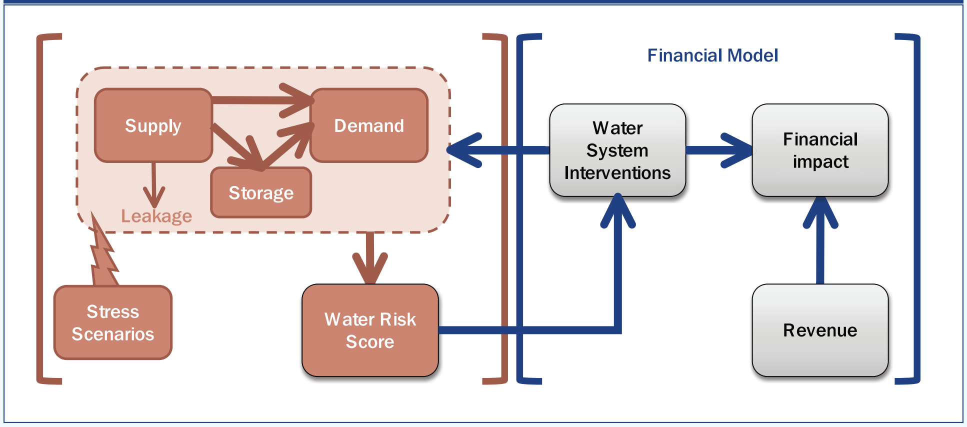
To illustrate how the model can be used, a set of eight investment-grade municipal bonds issued by public water and power utilities were selected and analyzed. The selected bonds were for utilities located in Alabama, Arizona, California, Georgia, and Texas, and were chosen based on the following criteria:

- **Region:** Bonds issued by utilities serving growing populations in areas experiencing increasing water stress;
- **Repayment Source:** Bond obligations paid through water or power sales revenues;
- **Maturity:** Bond repayment proceeds as far as possible to 2030;
- **Size:** Bond offering exceeds $40 million.

Modeling Water Risk: Water Utilities

For water utilities, undersupply is defined as the condition in which customer demand for water within the utility's service area exceeds the utility's water supply (see **Exhibit 1**).

Exhibit 1: The Water Risk Model – Water Utilities



Methodology for Modeling Water Risk

Water Demand Projections

For the purposes of this study, total projected demand for water in the period 2010 to 2030 has been estimated by using forecasts of population growth multiplied by per capita usage.

The water demand projections were generated by combining historical data and forecast projections to bound a distribution of possible annual population and usage per capita.

Wherever possible, forecast data was used to establish a best estimate projection for population and water usage per capita, which were combined to establish a best estimate of water demand. Where forecast data was unavailable, historical data has been used. Because actual water use may vary year-to-year, historical data was used to estimate the potential variability around the best estimate of water demands.

Water Supply Projections

The model disaggregates three distinct sources of water supply: local, external and storage.

Local sources are defined as water flows within the utility's political district or to which the utility has exclusive right. Local sources are constrained by the utility's legal right, typically defined in acre-feet per year.

Supply was simulated from local sources using the Water Evaluation and Planning ("WEAP") model, a software tool for integrated resources planning used widely in the water industry.[1] Using historical hydrological observations and climate scenarios, WEAP simulates physical surface water flows. Using historical information on water withdrawals along a particular water system, WEAP also models water withdrawals from competing users. In this way WEAP can simulate water deliveries, which is a function of available water in the watershed and competing demand.

Physical flows were modeled using four different simulations of supply for each bond location, based on climate change scenarios taken from an archive of 112 state-of-the-art climate model projections over the contiguous United States:[2]

- A scenario based on the historically observed data,
- A wet scenario from the National Center for Atmospheric Research, Community Climate System Model ("CCSM"),
- A dry scenario from Geophysical Fluid Dynamics Laboratory ("GFDL"), and
- A very dry scenario based on a Model for Interdisciplinary Research On Climate ("MIROC").

See **Exhibit 2** for additional information on two of the climate scenarios.

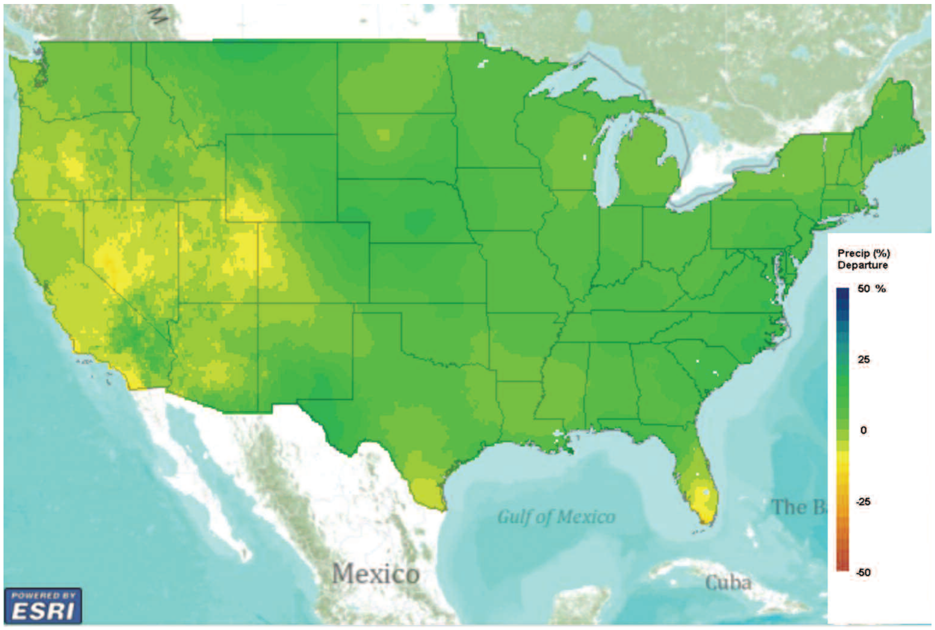
1 For additional detail on WEAP, see http://www.weap21.org/

2 Each climate scenario is a representation of possible future hydrology assuming a best estimate temperature rise of 3.4 °C with a likely range of 2.0 to 5.4 °C, consistent with the A2 scenario defined by the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change.

Exhibit 2: Change in Annual Precipitation by 2050 Under Two Climate Scenarios

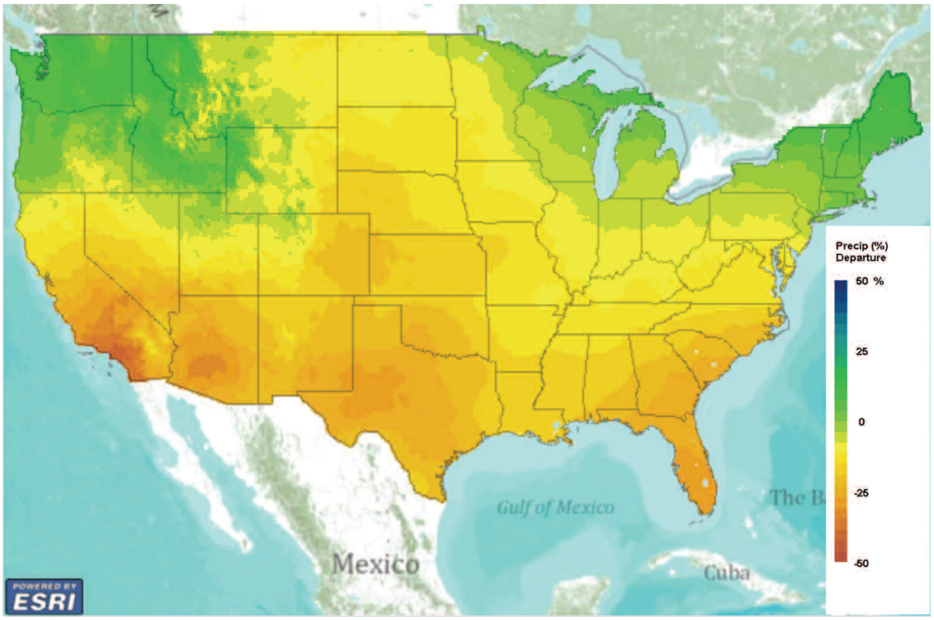
CCSM (Wet)

Model: CCSM3, SRES emission scenario A2



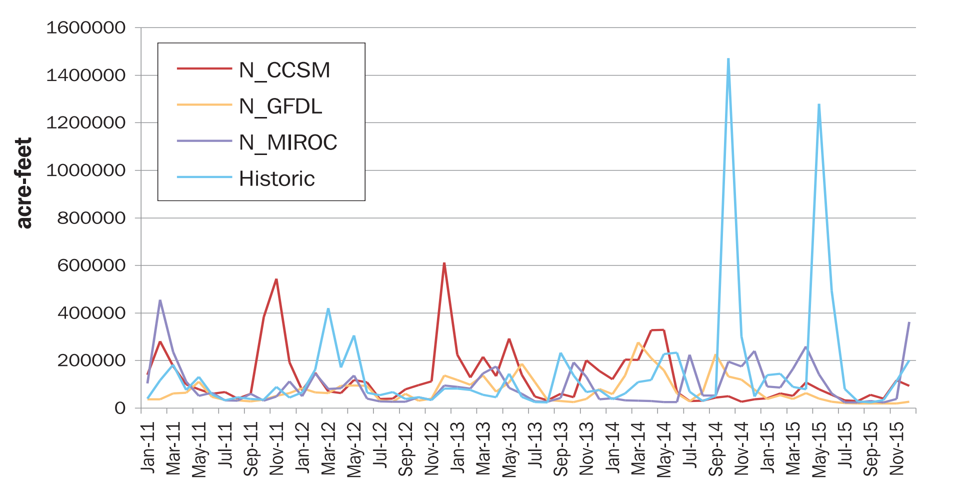
MIROC (Very Dry)

Model: MIROC3.2 (Medres), SRES emission scenario A2



Under each of these climate scenarios, WEAP produces a monthly simulation of water deliveries, as illustrated in **Exhibit 3.**

Exhibit 3: Trinity River Flows Using the WEAP Model



A representation of possible flows in the Trinity River near Dallas, Texas from January 2011 to November 2015, using the Water Evaluation and Planning (WEAP) model. Each trend line corresponds to one of the four climate scenarios employed in the model. Because the future is unknown, there is an equal probability of each scenario occurring over the modeled timeframe.

Storage includes reservoirs or groundwater supplies to which the utility has total right or which it shares with other users under defined allocations. Storage supplies were constrained by the utility's legal apportionment under normal flow years. In reality, utilities with junior water rights are likely to experience reduced deliveries from shared storage resources as utilities with senior rights retain the right to maintain or increase water deliveries during times of shortage. In some instances, including the case of the junior water rights of Glendale, Arizona, simulated storage deliveries in low-precipitation years are likely optimistic.

To capture the legal or physical constraints of extracting all available water from storage sources, the minimum volume of shared and wholly-controlled storage features was set at 30 percent capacity. This limit on available stored water may be the result of water levels falling below intake pipes, which are typically built above 30 percent capacity to avoid taking in the sediment at the bottom of any reservoir; regulatory limits on water withdrawals to protect fish and other aquatic organisms in the storage reservoir; or regulatory limits to prevent over-pumping of groundwater supplies.

External sources are water flows or storage that may be purchased from other users beyond the utility's political boundaries. External sources were constrained by the utility's legal right to access or purchase the water, where applicable. In some situations where the legal right was in excess of the delivered amount because of ongoing supply constraints, or where the utility has no legal right to the external source, the delivery from that external source has been limited to the level of recent historical deliveries—this is the case for Los Angeles deliveries from the Metropolitan Water Agency of Southern California.

To limit modeling requirements, water flows from external sources were not included in the WEAP modeling with respect to variability in natural flows. In reality, these sources are also subject to shortfalls from climate variability and climate change, making the assumption of available external supplies optimistic.

To account for water lost to *leakage*, a percentage of the total water supply was deducted based on current reported leakage rates, and then gradually increased over time based on the age of the utility's system.

Calculating Undersupply

The risk that water supplied from local sources is insufficient to meet demand was simulated by projecting and comparing the monthly supply and demand over the period 2011–2030.

For each monthly simulation in which water demand exceeded the supply of local water sources, the model deducts water from available storage. Storage was replenished on a monthly basis if inflows (precipitation) exceeded outflows (water delivered). When monthly demand exceeded the utility's allotment from local sources and storage, external sources of water to which the utility has legal recourse were applied to meet the shortfall.

For each utility, an initial water risk analysis was undertaken based on WEAP simulations of naturalized flows constrained by legal water rights. This established the *baseline scenario*, to which an annual score based on the extent of undersupply was assigned.

To understand the utility's resilience to external stresses on the system, including regulatory actions to protect environmental flows, legal challenges from other users, or severe droughts, *stress scenarios* were then applied to each utility (**Table 1**). Each stress scenario suppressed available water from either local, storage or external sources by a given amount. For each stress scenario, a separate annual score based on the extent of undersupply was assigned.

Table 1: Stress Scenarios Simulated – Water Utilities

Scenarios	Impact
Supply Reduction (High)	30% supply reduction for 3 years at most significant source
Supply Reduction (Low)	10% supply reduction continuously after impact at most significant source
Storage Reduction	50% capacity reduction in storage for 5 years
Storage + Supply Reduction	30% supply reduction for 3 years at most significant source + 50% capacity reduction in storage for 5 years

Scoring Water Risk

Local Sources. For each simulated month, a risk score was calculated that reflected the gap between local sources and demand. The scores were calculated on a geometric basis, such that the higher the proportion of undersupply, the higher the relative risk and therefore the higher the score (see **Table 2**).

Table 2: Scoring Matrix for Local Water Supply

	Level of Undersupply (as % of Simulated Demand)		
	0 – 10%	10% - 30%	>30%
Score at the Bottom of the Range	0	10	70
Marginal Score	1	3	6

If, for example, the simulated water supply from local sources in a single month is only 50 percent of simulated demand for that month, the model allocates a water risk score of 190 (70 + 20*6 = 190).

Methodology for Modeling Water Risk

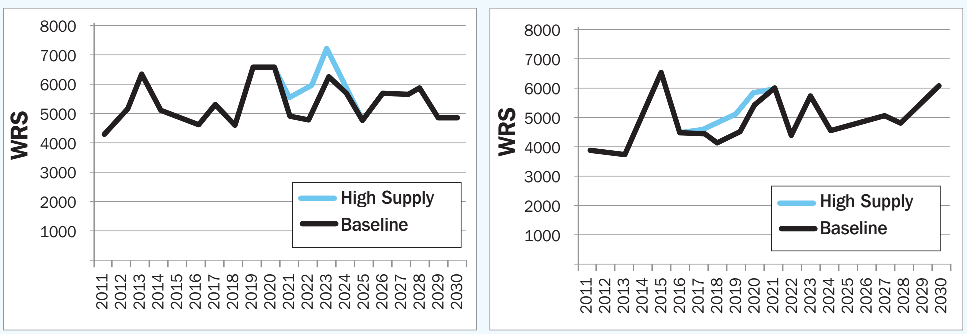
Storage. In months when local sources are insufficient to meet demand, the model debits the difference from the utility's storage. For each month, the model allocates a water risk score based on the percent of water remaining in storage.

% of Max Storage	Label	Score at Top of Range	Marginal Score	
<20%	20%	60	2	*i.e. storage of 5% capacity = 10 (60 + 2*15)*
<40%	40%	30	1.5	*i.e. storage of 32% capacity = 42 (30 + 1.5*8)*
<60%	60%	10	1	*i.e. storage of 55% capacity = 15 (10 + 1*5)*
<80%	80%	0	0.5	*i.e. storage of 70% capacity = 5 (0 + 0.5*10)*

External Sources. Reliance on external sources exposes utilities to natural reductions in flow along those systems and disruptions in delivery from increased competition for those resources. For systems with high dependence on external sources—including Los Angeles, Phoenix, and Glendale—supply stresses were applied to these external sources to test the systems' resilience to import reductions (see **Exhibit 4**).

Exhibit 4: Impacts of stresses on individual simulations

Example Simulation 1 **Example Simulation 2**



Two samples of high supply reductions (30% for 3 years) on LA's imported deliveries from the Metropolitan Water Agency of Southern California.

The model allocates a risk score for each month that all combined sources (local, storage and external) are insufficient to meet demand. There is a higher marginal risk score for higher degrees of undersupply:

% Undersupply	Label	Score at Bottom of Range	Marginal Score	
0-10%	0%	0	2	*i.e. undersupply of 5% capacity = 10 (10 + 2*5)*
10-30%	10%	20	6	*i.e. undersupply of 20% capacity = 80 (20 + 6*10)*
>30%	30%	140	12	*i.e. undersupply of 43% capacity = 296 (140 + 12*13)*

The model is dynamic in the sense that the water risk from local sources influences the risk from external sources. If the water supplied from local sources is insufficient to meet monthly demand, water is required from external sources to ensure demand is met. This in turn reduces the available water from external sources to meet any shortfall in supply from local sources in the following month.

Generating an Annual Risk Score

For each of the five scenarios (baseline plus four stresses), a risk score for each month was calculated by averaging across the hundreds of Monte Carlo simulations of monthly supply and demand. The monthly averages were summed in each year to create an annualized risk score for each year between 2011 and 2030, conveying when in time the utility may experience the highest degree of undersupply.

Generating a Scenario-Specific Single Risk Score

These annualized risk scores were averaged across the 20-year modeling period to produce a separate risk score for each of the five separate scenarios, including the baseline and four stress scenarios. While this single risk score for each scenario is a useful snapshot for comparing between utilities and scenarios, it does not convey when in time the utility may experience the highest degree of undersupply.

Comparing water risk

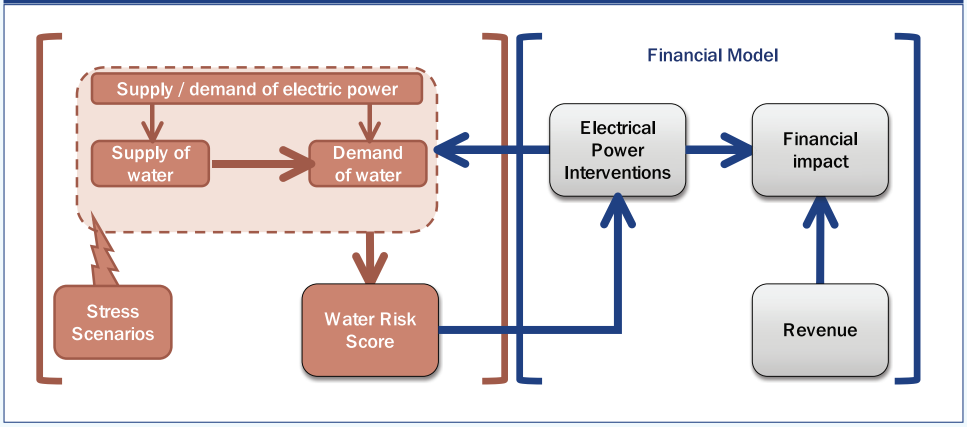
The framework enables comparison of the total water risk score across local and external sources, and allows comparison between the different water utility bonds at various levels of detail:

- For each bond and a given scenario, across months
- For each bond, across scenarios
- Across bonds

Modeling Water Risk: Electric Utilities

For electric power utilities, water risk is defined as the risk that the utility's demand for water cannot be met by available supply. The electric utility water risk scores reflect a combination of risk of undersupply for freshwater-cooled thermoelectric facilities and hydroelectric units, as well as regulatory risk for once-through saline-cooled facilities (see **Exhibit 6**).

Exhibit 6: The Water Risk Model – Electric Utilities



Water Demand Projections

For electric utilities, water demand is defined as the total water required by the utility to deliver electricity. This includes the electricity generated at the utility's wholly- and jointly-owned facilities, in addition to electricity delivered to the utility under power purchase agreements. In most cases, facilities contributing less than 150 MW to the utility's supply mix have been omitted to limit modeling requirements.

To calculate thermoelectric facilities' water demands, each facility's generation capacity (MW-hrs) was multiplied by the water intensity of generation (gallons/MW-hr), using water intensity factors provided by the National Energy Technology Laboratory (see **Appendix A**). Facility-specific water demand was then scaled by the facility's monthly capacity factor in order to capture seasonal variation in power generation.

Coal and nuclear units create the baseload for electric power utilities throughout the year. For most electric utilities, demand for electricity is greater in the summer months, when consumers run air-cooling systems, and lower during the cooler winter months. To allow for this feature, the electric utility model assumed some limited seasonality in the capacity factor of the coal and nuclear facilities by reducing the winter capacity by 30 percent to that in the summer months.

Natural gas units are typically relied upon to meet peak demand, and their generation increases accordingly during peak seasons. Monthly capacity factors based on typical levels of operation for gas power stations were used to reflect this seasonal variation for these units.

Hydropower stations are also typically relied upon to meet peak demand, but as many hydropower facilities need to release some water regularly to maintain ecosystems, manage flooding, and meet other water demands further downstream, these power stations will run throughout the year, meeting daily peaks in demand. As the model projects monthly supply and demand, the hydropower facilities have been modeled with only limited seasonal changes in capacity.

Water Supply Projections

Water supply for electric power was simulated using the Water Evaluation and Planning ("WEAP"), a software tool for integrated resources planning, created with water utilities to assist in planning for long-term climate effects.[3] Using historical hydrological observations and climate scenarios, WEAP simulates physical surface water flows. Using historical information on water withdrawals along a particular water system, WEAP also models water withdrawals from competing users. In this way WEAP can simulate water deliveries, which is a function of available water in the watershed and competing demand.

Physical flows were modeled using four different simulations of supply for each bond location, based on climate change scenarios taken from an archive of 112 state-of-the-art climate model projections over the contiguous United States:[4]

- A scenario based on the historically observed data;
- A wet scenario from the National Center for Atmospheric Research, Community Climate System Model ("CCSM");
- A dry scenario from Geophysical Fluid Dynamics Laboratory ("GFDL");
- A very dry scenario based on a Model for Interdisciplinary Research On Climate ("MIROC").

Using WEAP, the following variables for each facility's freshwater supply could be modeled:

- Total water volume
- Flow rate
- Water depth
- Water temperature

3 For additional detail on WEAP, see http://www.weap21.org/

4 Each climate scenario is a representation of possible future hydrology assuming a best estimate temperature rise of 3.4°C with a likely range of 2.0 to 5.4°C, consistent with the A2 scenario defined by the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change.

Calculating Undersupply

The risk that the freshwater supplied by the facility's water source is insufficient to meet demand was simulated by projecting and comparing the monthly supply and demand over the period 2011–2030. For each monthly simulation in which water demand exceeded the supply of usable water, the model applied a risk score.

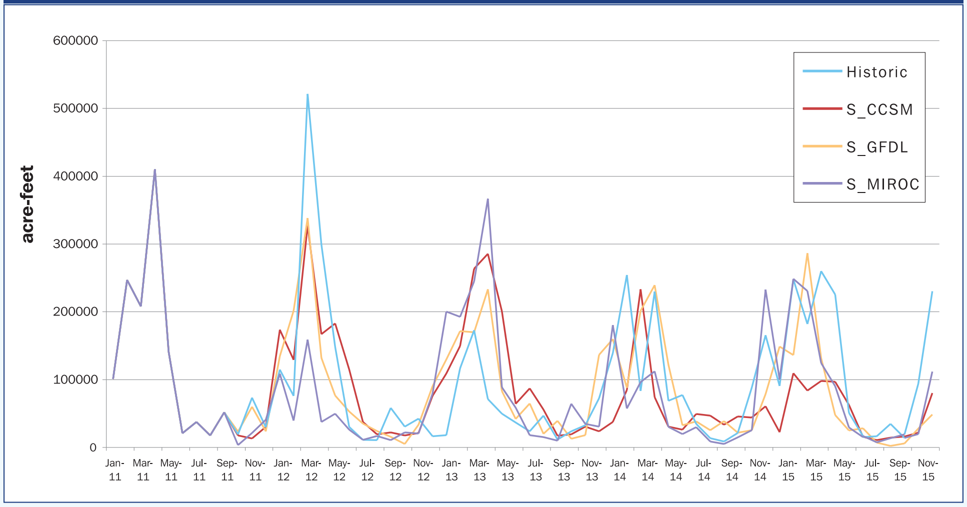
For thermoelectric facilities, undersupply was determined by comparing:

- Total water volume at the intake point to monthly water demand,
- Water depth at the intake point to the facility's cooling water intake structure depth, and
- Water temperature at the intake point to the facility's thermal permit, for once-through cooled facilities.

For hydroelectric facilities, WEAP was used to simulate electricity generation based on the depth, water flow rate, and volume of the impounded water. Undersupply was determined by comparing WEAP outputs to historical electricity generation at the specific hydroelectric facility.

For each utility, an initial water risk analysis was undertaken based on WEAP simulations of water flows at each generation facility using freshwater. This established the ***baseline scenario***, to which an annual score based on the extent of undersupply was assigned (see **Exhibit 7**).

Exhibit 7: Black Warrior River Flows Using the WEAP Model



A representation of possible flows on the Locust Fork of the Black Warrior River near Birmingham, Alabama from January 2011 to September 2015, using the Water Evaluation and Planning (WEAP) model. Each trend line corresponds to one of the four climate scenarios employed in the model. Because the future is unknown, there is an equal probability of each scenario occurring over the modeled timeframe.

To understand the utility's resilience to external stresses on the system, including regulatory actions to protect environmental flows, legal challenges from other users, or severe droughts exceeding the duration or intensity of the four climate scenarios modeled in WEAP, ***stress scenarios*** were then applied to each utility (**Table 3**).

For each stress scenario an annual score based on the extent of undersupply was assigned.

Table 3: Stress Scenarios Simulated

Electric Utility Scenarios	Impact
Supply Reduction (High)	30% reduction in water supply for 3 years
Supply Reduction (Mid)	30% reduction in water supply for 1 year
Supply Reduction (Low)	10% reduction in water supply for 3 years
High Demand	Facility operates at twice historic capacity, simulating effects of generation expansion
Low Demand	Facility operates at historic capacity

Scoring Water Risk

Risk scores were assessed for each generating facility. Risk scores were proportionate to the degree of undersupply, and weighted by fuel source as described in **Table 4**.

Monthly risk scores were assigned to each generating facility based on the percentage difference between available water and the water needed to generate power to meet seasonal demand. The monthly risk score for each facility was then scaled according to the fuel source, reflecting the relative importance for producing base load power to the grid.

Since nuclear and coal plants are relatively inexpensive to run, these fuel types typically provide the base load on a utility's grid. Disruption or diminished generation capacity at these facilities can impair supply across the grid, presenting significant costs to utilities. For this reason, risk scores for these plants are most heavily weighted. Natural gas is a relatively expensive fuel source typically relied upon to meet demand during peak hours, and as such it receives a lower weighting than nuclear or coal. Hydroelectric facilities provide inexpensive power but their capacity is limited by the available water, meaning they are typically relied upon to service peak demand. Lost production from a hydroelectric facility can be very costly to utilities if they must seek out replacement power, but utilities may also have more experience managing variability of hydropower production. For this reason, hydropower is weighted least heavily among all fuel types.

Table 4: Water Risk Scoring for Electric Generating Facilities

	Undersupply (as % of Selected Capacity Level)		
	0-10%	10%-30%	>30%
Risk Score at Bottom of Range	0	10	70
Marginal Risk Score	1	3	6
e.g. Risk Scores	6%: 6*1 = 6	16%: 10 + (6*3) = 28	36%: 70 + (6*6) = 106

	Nuclear	Coal	Natural Gas	Hydro
Scaling Factor by Energy Source	10	7	3	2

Monthly scores from each facility were summed to create a monthly ***baseline water*** risk score for the utility.

Monthly risk scores for each of the stress scenarios were calculated similarly, creating monthly ***stress scenario risk scores***.

Scoring Regulatory Risk for Saline-Cooled Facilities

The model also incorporates regulatory risks to saline-cooled facilities with once-through cooling systems, which may see difficulty in renewing permits due to their impact on aquatic organisms. Each saline-cooled, once-through facility was assessed a one-time risk score.

Generating an Annual Risk Score

For each of the scenarios (baseline plus stresses), the monthly risk scores for each electric power facility were summed to create an annual baseline or stress scenario risk score. The utility's monthly risk scores were summed in each year to create an annualized risk score for each year between 2011 and 2030, conveying when in time the utility may experience the highest degree of undersupply.

Generating a Scenario-Specific Single Risk Score

These annualized risk scores were averaged across the 20-year modeling period to produce a separate risk score for each of the scenarios, including the baseline and stress scenarios. While this single risk score for each scenario is a useful snapshot for comparing between utilities and scenarios, it does not convey when in time the utility may experience the highest degree of undersupply.

Comparing Water Risk

The framework enables comparison of the total water risk score across different generation facilities and allows comparison between the different water system bonds at various levels of detail:

- For each bond and a given scenario, across months
- For each bond, across scenarios
- Across bonds

Reasons Why Model Results May Be Wrong

There are several reasons why the results from this model may not fully represent water risk for the water and electric power utilities assessed.

- **Storage volume does not reflect competing withdrawals during times of shortage.** Although WEAP represents water withdrawals by competing users in the simulations of natural flows, the projected storage volumes do not incorporate withdrawals by other users. During times of drought or lower than average precipitation, utilities are likely to rely on shared storage resources to meet shortfalls in water flows. Thus storage volume represented in the model may be higher than volumes during an actual event of similar duration and intensity.

- **Junior water rights are not constrained during times of shortage.** The model allows utilities with junior water rights to extract their maximum water allocation even during times of shortage, when it is likely they would have to surrender a portion of allocated water to users with senior claims.

- **Natural flows for external sources are not modeled.** To limit modeling requirements, the model does not simulate naturalized flows from watersheds and systems considered external sources (for example, flows and competing deliveries on the Colorado River are not modeled for Los Angeles, Glendale, AZ or Phoenix). Simulated deliveries of external water supplies therefore assume sufficient supply when in reality droughts or climate variability may reduce the availability of external water supplies.

- **Stresses are not applied simultaneously.** Some utilities are likely to experience multiple stresses at the same time. For example, water utilities in California and Georgia have experienced reductions in water supply from drought at the same time that water deliveries were reduced to sustain environmental flows for aquatic species. Similarly, electric utilities may see drought-induced reductions in water flow as well as spiking water temperatures, creating multiple pressures on cooling water. Simultaneous stresses are likely to compound pressures and reduce the flexibility of utilities to respond. In the model, stresses are applied separately in randomly selected years for better comparability between utilities. The only case of simultaneous stresses in the model is overlapping high supply stress and storage stress for water utilities.
- **Utility has access to additional water sources which were not included in the bond prospectus.** The additional water sources would not have been included in the model and therefore the water risk may be overestimated.
- **Cooling water intake structures may be more vulnerable to water stress than assumed.** Public information on cooling water intake structures for thermoelectric facilities is of inconsistent quality, making it difficult to assess risk. Resources describing facility intake structures are few in number, and often sparing in information provided—for example, while the depth of the structure may be reported, no point of reference is provided to know whether the measurement is taken from the top, bottom or middle of the structure or what diameter of pipe is used. Even where facility-level data is provided on intake structures, typically there is no information on whether the facility withdraws water directly from an adjacent river or from a holding pond. For the purposes of this report, it was assumed that intake structure depth, when reported, is measured from the bottom of the pipe. For river-cooled facilities, where the reported intake pipe depth is lower than river depth (suggesting that the water is withdrawn from a holding pond), the likelihood of water height dropping below the intake structure was not modelled, for lack of information on the geometry of the holding pond.

CREDIT RATING SCALES

	Standard & Poor's	Fitch	Moody's
Investment Grade	AAA	AAA	Aaa
	AA	AA	Aa
	A	A	A
	BBB	BBB	—
Speculative Grade	BB	BB	Baa
	B	B	Ba
	CCC	CCC	B
	CC	CC	Caa
	C	C	Ca
	D	D	C

S&P and Fitch additionally define ratings as Stable (no expectation of rating change) or Negative (expectation of rating adjustment to reflect diminished credit quality).

Moody's appends numerical modifiers 1, 2, and 3 to each generic rating classification from Aa through Caa. The modifier 1 indicates that the obligation ranks in the higher end of its generic rating category; the modifier 2 indicates a mid-range ranking; and the modifier 3 indicates a ranking in the lower end of that generic rating category.

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