Workshop materials and presentations available here: http://epa.gov/importanceofwater

1. Overview of Workshop Agenda

Speaker

- Brian Morrison, Principal, Industrial Economics, Incorporated

Presentation

- Workshop Objectives:
    - Increase understanding of water's contribution to the economic welfare of the nation.
    - Aggregate existing knowledge about the role water plays in the U.S. economy.
    - Improve the ability to quantify the economic value of water to society, recognizing that not all values can be conveyed in dollars.
    - Identify areas where additional research would be useful.
    - Help launch a broader discussion of the role of water in the economy and the information required to support economic decisions related to water.
- EPA's study consists of five components, including a background report, expert papers, this technical workshop, a synthesis report, and a public symposium.
- This workshop will present EPA-sponsored research and invite independent input from expert panelists in both the public and private sectors on their use and management of water resources, methods and tools that analysts use to generate information that can support decision-making, and gaps in the information needed to improve management and use of water resources.
- Charge questions for panelists:
    - How is water economically important to you - i.e., your business, your industry, your agency, the members of your association, or the stakeholders/clients with whom you work?
    - What water-related strategic decisions do you make?
    - What water-related information do you need to make better strategic decisions?
    - What can EPA or others do to help you obtain this information?

2. Opening Remarks

Speaker

- Michael Shapiro, Principal Deputy Assistant Administrator, U.S. EPA Office of Water

Presentation

- This workshop is part of a larger effort to address the importance of water to the U.S. economy and identify areas where additional research is necessary.
- This workshop is an important part of a collaborative process that will ultimately lead to a synthesis report and a public symposium on December 4th at American University (registration

will open in October). The symposium will present the initial findings of the work EPA has been doing and engage the broader community in discussion about the importance of water.

- EPA designed this particular workshop to:
    - Bring together a diverse group of individuals (organizations/institutions represented, disciplinary backgrounds – economists, decision-makers, industry reps);
    - Enrich the dialogue and ensure the right questions are being asked;
    - Improve its understanding of the importance of water to various sectors of the economy; and
    - Promote ongoing dialogue among those affected by future availability of water (of sufficient quantity and quality).
- EPA hopes to work with others to contribute to a better understanding of the economic importance of water. To find information resources related to this effort and this workshop, one can search for "EPA Importance of Water Economy" to reach EPA's website. One can also search for "Clean Water 40" to learn more about efforts to recognize accomplishments of the Clean Water Act.

Discussion

- This effort does not focus on valuing ecosystem services and other non-market benefits directly, but rather goods and services in market economy. It does not seek to capture the whole value spectrum; rather, it seeks to promote discussion around how the market economy is affected by the availability and quality of water.

3. Perspectives on the Economic Importance of Water: Sponsored Research

3.A. The Importance of Water to the U.S. Economy: Background Report

Speaker

- Brian Morrison, Principal, Industrial Economics, Incorporated

Presentation

- Why does EPA want to look at water's use and value?
    - The theoretical ideal in classical economics is that well-informed and competitive markets operate and use water in ways that are economically efficient (i.e., in ways that maximize the benefits derived from the resource).
    - In reality, the necessary conditions for efficient water markets are difficult to achieve. Water is a public resource with imperfect markets and potential externalities.
    - Better information is needed to help decision-makers in the private and public sectors derive greater value from the nation's water resources.
- EPA developed the background report in order to:
    - Summarize information on water's use and the importance of water to key sectors;

    - Provide a baseline understanding of important data and concepts for analyzing the value of water; and
    - Catalyze further efforts to improve information resources to support public and private sector decision-making with respect to water resources.
- The background report does not attempt to estimate the total value of water to the U.S. economy, nor does it analyze the costs or benefits of any regulatory actions.
- The background report follows a sector-by-sector organization that includes an overview of each sector, water use (quantities, sources, trends) within that sector, special topics (e.g., water quality concerns or supply issues) relevant to that sector, and available estimates of water's value to that sector.
- Observations on empirical estimates of the value of water:
    - Available estimates on the value of water in off-stream uses vary widely.
    - Estimates often reflect *average* values, which likely overestimate *marginal* values but are not indicative of *total* values.
    - Significant variation occurs both within and across uses.
    - The variability of estimates reflects regional differences, availability of substitutes for water, the different methods used to develop estimates, and the multiple dimensions of water that affect its value in a particular use (e.g., when and where it is supplied, whether the supply is reliable, and the quality of the water).
- The report discusses a macroeconomic framework that groups industries into four mega-sectors:
    - *Primary*, including agriculture, forestry, fishing, and mining.
    - *Secondary*, including utilities, construction, and manufacturing.
    - *Tertiary*, including transportation, wholesale trade, and retail trade.
    - *Quaternary*, including finance, insurance, real estate, and public administration.
- Direct use of water is concentrated in the primary and secondary mega-sectors, which produce output that supports economic activity in the tertiary and quaternary mega-sectors, meaning that water supply shocks can directly or indirectly affect the economy as a whole.
- As the report notes, water scarcity is already a problem in many areas and is expected to become more serious in the future, due to population and economic growth and the expected effects of climate change. However, several major off-stream water use sectors have made significant progress in reducing water withdrawals (through technological and behavioral changes), and there is room for further improvement in water use efficiency.

Discussion

- This study is limited to focusing on water's impact on the market economy. It does not address non-market benefits, nor does it consider the impacts of regulatory actions, such as the Clean Water Act or the Endangered Species Act.
- Though the report does not specifically focus on technological innovation, it does discuss how improvements in water use efficiency have affected water use over time. It also notes how

environmental regulation has affected trends in water use in certain sectors, considering environmental in-stream uses of water as one of many competing demands for water.

- The report considers both water withdrawals and water consumption. In order to get a complete picture of water use and its economic impacts, one must consider how water is withdrawn, how it is used, how it is consumed, where it is transported, and where it is returned. What factors are considered has a large impact on value estimates.
- Though the report is organized by economic sector, it does consider the importance of regional factors that affect water use and water values. Where data and information are available, the report discusses regional variation in water uses and values within each sector.

3.B. The Impact of Water on Strategic Decisions: Case Studies of Five Key Industrial Sectors

Speaker

- Mike Matichich, Principal Technologist and Technology Leader for Financial Services in Water, CH2M-Hill.
- Co-authors: Marek Mierzejewski, Bill Byers, Dan Pitzler, and Sartaz Ahmed, CH2M-Hill.

Presentation

- This presentation focuses on the importance of water in five industrial sectors: semiconductor, chemical, oil & gas, mining, and electric utilities. In these industrial sectors, water can serve as a direct input or an indirect input (i.e., supporting operations). In this context, both water quantity and quality influence the value of water.
- Several factors influence the pricing of water and wastewater services. Guidance documents by industry associations recommend basing rates primarily on the cost of providing service (COS), though they recognize the need for occasional deviations from COS-based pricing (e.g., reduced rates for large customers to encourage economic development). Regional variations in input costs and system-specific factors (e.g., age of infrastructure) can lead to variations in water rates, as can differences in public utility regulations.
- Several factors are changing the way that industrial users of water manage their use of water resources:
    - Climate change impacts to the water cycle can impact water availability and quality.
    - Population growth, new technology, and industrial and economic development can increase competition for scarce water resources.
    - Government regulations can impose requirements for reporting on water use and disposal.
- Companies are focusing on water management and self-initiated water footprint reporting.
    - Water management includes monitoring water usage, improving efficiency, finding engineering or economic solutions, contingency planning, and/or collaborating to improve water management.

    - Self-initiated reporting follows a trend whereby companies are finding value in reporting on water use. Interested parties include both stockholders and stakeholders in the state or local community.
- Case studies of companies in the semiconductor (Intel), mining (Rio Tinto), and chemical (Dow) industries show that companies are increasingly aware of the importance of management, efficiency, and sustainability with respect to utilization of water resources. These examples show that firms are adopting best practices to maximize their position with regard to water resources.

Discussion

- Though the examples of water conservation measures presented are anecdotal, there is a movement towards testing approaches and applying them more broadly throughout organizations. This effort did not specifically explore how assessments are made regarding where to apply water conservation measures, though in the five case studies developed for the paper, initial applications are usually where there are more significant supply constraint or pricing issues, with opportunities to realize savings by reducing water use.
- Beyond the economic motive for water management, companies like Intel and The Dow Chemical Company recognize the increased visibility of water among stakeholders and within communities where they operate. They realize its value to the community beyond just the value to their own bottom line.
- Regarding water rates, cost-of-service pricing generally reflects average costs, rather than marginal costs. Water prices do not consider opportunity costs, an important component of economic value. Nevertheless, it is important to consider both values and prices when assessing the role of water in the economy and the ability of firms and other actors to influence the use of water in the economy. One would not say that price equals value, but they are both important considerations in the way that firms make decisions about water, and are both ultimately salient factors with regard to the broader topic of the importance of water to the US economy.

<u>3.C. Lessons from Short-term Supply Disruptions: Providing Confidence and Context to FEMA's Methodology</u>

Speaker

- Craig Aubuchon, Associate, Analysis Group
- Co-author: Kevin Morley, Security and Preparedness Program Manager, American Water Works Association

Presentation

- The authors estimated the costs associated with short-term supply disruptions using a methodology employed by the Federal Emergency Management Agency (FEMA), and examined the sensitivity of the estimates to more precise data on the cost of such disruptions by state.

- FEMA uses a standard value of water as part of benefit/cost analyses conducted for its hazard mitigation grant program. FEMA's value of water is $93/person/day, representing the economic loss to businesses ($40/person/day) and residents ($53/person/day) from a disruption in water supply. FEMA assumes a complete loss of water delivery (aside from a minimum supply of 6.6 gallons/person/day assumed to be provided by the government as an emergency service), so its estimates relate to the marginal value of water during times of scarcity.
- FEMA estimates business losses from a water supply disruption using industry-specific GDP and resiliency factors, or the percentage of output that can be maintained during a short-term disruption. FEMA uses resiliency factors from a 1991 study and national data on industry contributions to GDP; to assess the sensitivity of FEMA's estimates to these variables, the authors used resiliency factors from a 2002 study and state-level GDP data.
- To estimate residential losses, FEMA uses a national estimate of water use and the mean value of the price elasticity of demand for water from a 2003 meta-analysis. The authors used state-level water use data and both median and short-run elasticity estimates from the same 2003 study.
- From their analysis of business losses, the authors found that using state-level GDP data did not significantly change the national estimate, but using different resiliency factors increased the value estimate from $40/person/day to $66/person/day. Their analysis of residential losses showed that using state-level data on water consumption lowered the value estimate from $53/person/day to $22/person/day, but using alternate estimates of elasticity of demand greatly increased the value estimate to as high as $2,046/person/day.
- One conclusion from this study is that estimates of the value of disruptions in water service depend in large part on estimates of how people respond to water shortages, in the form of industry resilience factors (for business losses) or price elasticity of demand (for residential losses).

Discussion

- The authors found variation in state-level business loss values due to different industry mixes. Some industries are less resilient to water shortages; states with a larger share of such industries face proportionally greater losses when supply disruptions occur. The state-level variation in residential losses is influenced by differences in per-capita water consumption.
- The question of how to allocate scarce water resources during droughts is one that will increase in importance. Texas struggled with how to allocate water during its recent drought. It is important to understand the impact that water allocation decisions can have on GDP. This kind of research can inform those decisions.

<u>3.D. The Value of the Marginal Product of Water: Estimation of a Stochastic Production Function for U.S. Agriculture at the County Level</u>

Speaker

- Andrew Zaeske, Postdoctoral Researcher, Centre for Environmental and Resource Economics, Umeå University and Swedish University of Agricultural Sciences

Presentation

- The author used econometric analysis to assess how different factors affect whether farms are efficiently using various inputs – including water – as part of their agricultural production.
- The author developed a stochastic frontier model, which estimates expected agricultural output assuming optimal use of inputs (employment, intermediate inputs, water, and land). The stochastic frontier model used panel data that controlled for time and county-specific effects, as well as differences across ecological regions. A second model was then used to show how different factors affect whether farms are operating "within" that frontier, i.e., using inputs sub-optimally. Factors assessed include climate variables, farm size distribution, and acreages of different crop types.
- The analysis looked at farms at the county level, splitting counties by population density into rural, micropolitan (near a population center of 10,000-50,000 people), and metropolitan (near a population center of more than 50,000 people).
- The regression analysis found that in rural counties, additional use of water increased agricultural output, but in micropolitan and metropolitan counties, additional use of water decreased agricultural output. This finding suggests that farms in more densely populated areas are making inefficient use of water and could actually increase production by decreasing their water consumption.

Discussion

- Given the counter-intuitive conclusion of this analysis, it is important to investigate the data, methods, and assumptions used to arrive at that conclusion.
- Many workshop participants expressed objections to the analysis's assumptions and methods, including whether it properly accounts for the geographic distribution of farms, whether a farm's source of water (e.g., local river, groundwater, transported water) is accounted for, whether the division of counties by population density is appropriate, and whether differences in crops might explain differences in how farms use water. Due to limitations in available data, the analysis was not able to account for all of the factors mentioned by workshop participants.
- Aside from methodological concerns about this study, it is important to recognize that the economic perspective does not necessarily account for all relevant values. One should be cautious about drawing conclusions about water allocations based solely on such analysis.

<u>3.E. Embedded Resource Accounting: Evaluating the Comparative Intensity of Water Use in Multiple Sectors of the U.S. Economy</u>

Speaker

- Benjamin Ruddell, Assistant Professor, Polytechnic Department of Engineering, Arizona State University

Presentation

- The author used methods outside of classical economic valuation to assess the value of water, namely Embedded Resource Accounting and Embedded Values Assessment.
- Embedded Values Assessment (EVA) is a measure of value intensity, or the ratio of a value produced by a particular process to its impact on the stock of a particular resource. Values can be measured in several ways, such as people, endangered species, gross revenue, or value added.
- Embedded Resource Accounting (ERA) is the ratio of the production of a particular resource through a particular process to that process's impact on stocks of other resources.
- ERA can examine the embedded water, or "water footprint," in other resources. For example, one can compare the amount of water required to generate a unit of electricity across different states to assess how trade in electricity affects water use patterns.
- EVA can relate water use to economic activity. As an example, the author examined the water intensity of Arizona cities of different sizes, using different measures of value. This analysis showed that city size was correlated with the value intensity of water as measured by state sales and income taxes, but not with the value intensity of water as measured by property tax.
- EVA can also be used to examine impacts of different water-consuming processes on a watershed level. As an example, the author presented estimates of capacity footprints, or the percent of available capacity that a particular process could deplete, in the Great Lakes region. He then showed how different economic processes vary in value intensity with respect to their capacity footprints, in some cases exceeding the total capacity of the stream segments where they are located.
- EVA and ERA methods can be used to reveal patterns in how water use is embedded in different economic processes and how water is associated with the creation of goods and services that are valued by the public.

Discussion

- When considering capacity footprints, it is important to note that water scarcity can be highly temporal, particularly in the Great Lakes region. The example in the presentation only considers August flow conditions. Generally, there is no scarcity in the Great Lakes area except during low-flow seasons.
- It is also important to note that the value of water presented in this analysis differs from the strict economic definition of value and may significantly undervalue water by not considering opportunity costs.

<u>3.F. The Value of Water to the Economy of Nevada: Methods for Analysis Using a Computable General Equilibrium Model</u>

Speaker

- Betsy Fadali, Research Associate, Department of Economics, University of Nevada, Reno

- Co-authors: Kimberly Rollins, Associate Professor, Department of Economics, University of Nevada, Reno; Shawn Stoddard, Senior Planner/Senior Resource Economist, Truckee Meadows Water Authority

Presentation

- The authors' work evaluated computable general equilibrium (CGE) models as a tool for assessing the value of water and examined where, how, and why such models might be used.
- Because of unique aspects of how water is used in economic activity, it is not possible to estimate a single value for water; arguably, it makes more sense to consider how the use of water produces economic value within a particular system.
- CGE models can consider the multiple uses of water in an economic system and provide estimates of how changes in water use affect social welfare in a particular time period.
- CGE models explicitly model complicated interactions and feedbacks that exist in economic systems, allowing them to capture indirect effects as well as direct effects of any changes to a system. For example, the 2012 drought will not only have a direct effect on the supply of multiple food products, but will also affect labor and capital markets, thereby affecting household incomes, which can indirectly affect demand for those same food products.
- A CGE model for water would need data on water intensity factors, or the amount of water required for a particular unit of economic activity in a given sector. Though USGS reports water use by broad sector, more detailed data are needed. The specification of water use in production functions, as well as baseline values for water prices, would also be important.
- Use of water CGE models has increased in recent years, though less so in the U.S. Most applications have compared scenarios with and without functioning markets for the exchange of water rights.
- CGE models can play an important role in assessing broad impacts of changes in water use on economic activity. Because the value of water changes over time and across economic sectors and geographic regions, it is important to use the "computational laboratories" that CGE models offer to capture key indirect effects, interactions of multiple markets, and large-scale welfare changes.

Discussion

- CGE models can account for different uses of municipal water by differentiating between inside and outside water use, incorporating different demand factors for each category.
- Beyond just looking at changes in total economic welfare, it is important that CGE models consider distributional impacts of any welfare changes caused by changes in water use.
- Models can be set up to examine the impacts of short-term water shortages or long-term water shortages, depending on the policies or scenarios being examined. Water shortages and policies for responding to them (e.g., rationing) can be imposed exogenously on a modeled system.
- The typical CGE model focuses on water quantity, not quality, though there are some that focus just on water quality. The author is not aware of any that combine both water quantity and

water quality. Quality is one of the important aspects of water that is underexplored for this type of model.

Urban Growth and Water

Speaker

- Anita Chaudhry, Assistant Professor, Department of Economics, California State University, Chico
- Co-author: Edward Barbier, John S. Bugas Professor of Economics, Department of Economics and Finance, University of Wyoming

Presentation

- The authors first developed a theoretical model relating economic growth in an urban economy to several variables, including population growth, water consumption, publicly provided water supply, and total water availability.
- The model suggested three testable hypotheses:
  (1) An increase in publicly provided water supply per capita will increase economic growth,
  (2) An increase in population growth will increase economic growth, and
  (3) An increase in total water availability per person will decrease economic growth.
- With panel data of urban counties from 1985-2010, the authors then used regression analysis to relate economic growth rates to population growth rates, per capita water supply withdrawals, and total water withdrawals by all sectors. Because it is difficult to measure total water availability, total water withdrawals were used as a proxy for each county. The authors also controlled for population factors (age, education, and race), and climate factors (precipitation and temperature).
- The results of the regression supported hypotheses (1) and (2) but did not support hypothesis (3).
- The results of this study support the idea that enhancing public water supply can contribute to economic growth, though it does not distinguish between sustainable water use and unsustainable water uses (e.g., groundwater mining).

Discussion

- One graphic used in the presentation showed increasing water use in municipal water systems over time. It is important to note that while total water withdrawals have increased steadily from 1950 to 2005, per capita withdrawals have actually decreased over the past two decades.

3.G. Does a Water Economy Exist? The Impact of the Availability of Water on Employment in U.S. Metropolitan Areas

Speaker

- Craig Aubuchon, Associate, Analysis Group

Presentation

- The author sought to examine the idea of a "water economy," i.e., that availability of reliable, high-quality public water supplies can confer a competitive advantage to a particular area, allowing it to attract industries and yielding greater economic development (all else equal) than less water-rich areas.
- Because the study focused on economic development, rather than economic growth, it used changes in employment as its dependent variable, rather than change in GDP. Specifically, the author hypothesized that measures of local water availability will be positively correlated with changes in employment.
- The study used shift-share analysis, which attempts to determine what portion of a change in employment is due to national trends, what portion is due to industry-specific factors, and what portion is due to comparative advantage (i.e., factors specific to a certain area that confer an advantage over other areas). The author related the comparative advantage portion of changes in employment to total industrial withdrawals of water and several measures of developed water infrastructure. The regression analysis also controlled for demographic and social factors expected to affect economic development.
- The analysis found that a metropolitan water supply system's peaking factor (a measure of the variability of water demand) is negatively correlated with employment growth, that a system's efficiency factor (a measure of how closely total demand matches maximum supply capacity) is positively correlated with employment growth, and both water rates and water withdrawals have no significant correlation with employment growth.
- Though caveats apply due to limitations on the data used in the analysis, the results of the regression suggest that developed water capacity may affect local job creation, but water rates and total water withdrawals do not significantly affect economic development. In short, water resources matter, but infrastructure to deliver water appears to matter more.

Discussion

- Though the analysis suggests that a high peaking factor is correlated with a decline in employment, this does not necessarily mean that the peaking factor is *causing* the change in employment. Residential water use tends to have a higher peaking factor than industrial water use, so changes in residential demand could be driving changes in peaking factors. Because of limitations in the data used for the analysis, it is difficult to measure the direction of causality.
- Similarly, job growth may be correlated with efficient water use, but it may be that communities with rapid population growth will have more efficient delivery systems simply because the systems are newer.
- It is important to note that water supply limitations will not affect all industries, meaning that cities can grow through development of less water-intensive industries even if they have less developed water available than other areas.
- Models such as this may not account for the fact that allotments of water to industrial users may be set by policy. Policymakers make a value judgment in some cases that residential use is

prioritized over industrial use, limiting industrial access during times of scarcity. Restricting industry access to water can have long-term impacts on an area's economic growth. As an example, if electricity generators must seek alternative sources of water, the cost of electricity increases, which can drive other industries away.

4. Lunchtime Speakers

The National Water Census

Speaker

- Eric Evenson, Coordinator, National Water Census, U.S. Geological Survey

Presentation

- USGS objectives for the water census:
    - Provide technical information, data, and tools to stakeholders and decision-makers.
    - Water Availability Analysis: the process of determining the quantity and timing-characteristics of water of sufficient quality to meet both human and ecological needs.
- Data sources include existing USGS data networks dealing with surface water, groundwater, and water quality.
- USGS seeks to develop a nationwide system that provides technical information on water budget components such as precipitation, evapotranspiration, water storage, surface water, groundwater, ecological needs, water withdrawals, return flows, consumptive uses, and more.
- This information will be delivered via a web application.
- Developing this information system will require:
    - Using new methods to estimate water use (e.g., estimating flows for ungaged streams).
    - Developing models of water use based on land use.
    - The ability to track water from the point of withdrawal through to return of flow.
    - Improved ability to understand water needs for wildlife and habitat.
    - Assessing groundwater's role in influencing water availability.
- To work towards this goal, USGS is conducting geographically focused studies in three selected watersheds: (1) the Colorado River; (2) the Delaware River; and (3) ACF Rivers.
- The ultimate goal is to provide stakeholders with technical information and tools that they can use to answer the questions they are facing.

Discussion

- The data are in the public domain and available to all.
- USGS plans to expand the stream-gaging network by 2,000 gages, but these efforts depend on securing necessary funding.
- USGS would like to be involved in helping water agencies work together to improve water management and is willing to assist in intergovernmental initiatives.

The Importance of Water to the U.S. Economy: A Perspective from the USGS Science and Decisions Center

Speaker

- Carl Shapiro, Senior Economist, Energy and Minerals, and Environmental Health and Co-Director, USGS Science and Decisions Center

Presentation

- The USGS mission is to provide reliable scientific information to:
    - Describe and understand the Earth;
    - Minimize loss of life and property from natural disasters;
    - Manage water, biological, energy, and mineral resources; and
    - Enhance and protect our quality of life.
- This mission reflects the National Research Council Review of USGS (2001), which recommended that "USGS should shift from a more passive role of study and analysis to one that seeks to convey information actively in ways that are responsive to social, political, and economic needs." In other words, USGS should conduct science to inform societal decisions.
- USGS performs economic analyses on three main topics:
    - Value of scientific information;
    - Value of natural resources; and
    - Benefit-cost analyses of alternative decisions and scenarios.
- These economic analyses assist stakeholders and decision makers in making informed decisions regarding the impacts of resource management, use and conservation.

Discussion

- USGS's work recognizes the importance of considering both market and non-market values of natural resources. Ignoring non-market values leads to inefficiencies.

5. The Economic Importance of Water: Independent Perspectives

5.A. Primary Mega-Sector: Agriculture and Energy Resources

5.A.I. Agriculture

The Economic Importance of Western Irrigated Agriculture: Water Values, Analysis Methods, Resource Management Decisions

Speaker

- Darryll Olsen, Principal, The Pacific Northwest Project

Presentation

- In the context of agriculture, this presentation addresses income impacts, opportunity costs, and food security ties to "silent" opportunity costs.
- Economic impacts from the irrigated agriculture industry come from direct agricultural production, agricultural services, and food processing.
- The building blocks for understanding economic impacts and opportunity costs related to irrigated agriculture include:
    - Total irrigated acres in the Western U.S. (approximately 42.30 million acres in 2008)
    - Estimated agricultural production value from irrigated land in the Western U.S. (over $103 billion in estimated agricultural production value in 2010 dollars)
    - Annual income impact associated with irrigated agriculture (over $128 billion in 2010 in direct and indirect annual income impact for the Western U.S., according to IMPLAN analysis)
- Examples of estimates of the direct net value (including opportunity costs) of water used for irrigated agriculture include:
    - Columbia River Basin (based on water markets and annualized capital value): $1,500/acre-ft
    - Western irrigation range (based on water markets): $1,500 - $2,500/acre-ft
    - Western U.S. (based on municipal sector alternative costs): $2,500/acre-ft
- What are "silent" opportunity costs for irrigated agriculture?
    - Considerations such as food security, food production, and distribution logistics contribute to economic impacts in metrics such as tax contributions, government services, and disposable income.
    - Irrigated agricultural production in turn affects food pricing, which subsequently impacts disposable income, consumption expenditures, and GDP.
- How can valuation of opportunity costs related to irrigated agriculture be improved?
    - Empirical analysis (e.g., benefit-cost analysis) can help improve understanding of direct opportunity costs.
    - Consideration of how changes in irrigated agriculture impact food security and the greater economy can help quantify "silent" opportunity costs. Impact measures include price index changes for food and/or personal consumption expenditures.

Discussion

- Discussion of this presentation was reserved for the plenary session.

<u>The Value of U.S Irrigated Agriculture & Conservation Challenges for a Sustainable Future</u>

Speaker

- Glenn Schaible, Resources and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture (USDA)

Presentation

- This presentation draws from the USDA Economic Research Service's recent publication of Economic Information Bulletin Number 99 (September 2012), titled "Water Conservation in Irrigated Agriculture: Trends and Challenges In the Face of Emerging Demands." (available here)
- Irrigated agriculture accounts for a significant portion of U.S. agricultural production (40% of the value of farm sales in 2007).
- In the U.S., major crop categories for irrigated agriculture include forage, corn, soybeans, orchards, rice, cotton, wheat, and vegetables.
- Population growth and economic development represent continuing drivers for increased water demand and competition.
- Increasing competition for water and increased water scarcity represent emerging water challenges for irrigated agriculture.
- Competing demands for water include Native American water-right claims, in-stream (environmental) flow regulations, water needs for energy expansion, and climate change (supply/demand) impacts.
- Challenges for agricultural water conservation are twofold:
    - Continue to enhance the irrigation efficiency of agricultural operations, but with greater emphasis on improving "irrigation production systems" by integrating improved on-farm water management practices (such as use of soil- or plant-moisture sensing devices, commercial irrigation scheduling services, and computer-based crop-growth simulation models) with efficient irrigation application systems.
    - Continue to integrate on-farm water conservation efforts with institutional (watershed-level) water management mechanisms (such as conserved water rights, drought water banks, option water markets, and irrigated acreage retirement).
        - USDA participates in watershed-scale agricultural water conservation through partnership agreements at the federal, state, and local level.
- Integrated water-conservation policies allow producers and stakeholders to:
    - Jointly recognize the values of water across competing demands.
    - Facilitate water reallocation for the purposes of reducing crop consumptive water use while maximizing farm-economic returns.

Discussion

- Discussion of this presentation was reserved for the plenary session.

5.A.II. Energy Resources

Coal Mining and Water

Speaker

- Eric Fry, Director of Regulatory Affairs, Peabody Energy

Presentation

- Coal operations use water from surface water, groundwater, and offsite sources.
- Major uses of water at coal mines include coal preparation (which recycles water through a closed-loop system), dust control, and operation of underground equipment.
- Coal mines must also deal with excess water produced or gathered at mine sites.
- What are the effects of coal mining on water?
    - Most water-related mining pollution issues occurred at "pre-law" mining sites developed prior to the introduction of environmental regulations, most notably the Surface Mining Control and Reclamation Act (SMCRA)
    - Water routed to groundwater or surface water sources must meet water quality standards.
    - Several options are available for improving water quality, including implementation of riparian buffers, natural stream restoration, reducing erosion, flattening of topography, or improving the permeability of disturbed areas.
    - Several studies show beneficial effects of post-mining reclamation on aquatic biology.
- What regulations and best management practices (BMPs) affect management of water at mining sites?
    - Regulations governing mine sites include state water quality standards, the NPDES 402 Program, the State 401 Certification Program, the U.S. Army Corps of Engineers 404 Program, Federal agency comments from the EPA and Fish and Wildlife Service, and SMCRA.
    - BMPs for mining sites include separating clean and dirty water, recycling water onsite, selective placement, and rapid reclamation and restoration of mining sites.
- Statistics show that coal mining is not a water-intensive industry. USGS estimated in 2005 that mining represents approximately 1 percent of total water withdrawals.
    - Estimates of water use per ton of coal produced range from 5.2 gallons (in a 2003 study) to less than 2 gallons (in a 2012 study).

Discussion

- Past mining practices have caused significant damage to water resources. For example, over 2,500 miles of streams have been affected by mine-related pollution in Pennsylvania. It is estimated that this pollution has caused $2 billion of lost recreation in those stream reaches. However, most mine-related pollution problems were "pre-law," or before SMCRA. Since intensive regulations have been introduced on mining, there have been far fewer instances of significant pollution issues.
- Excess water, which primarily is an issue for Peabody's Australian operations, refers to possible flooding from water caught in site impoundments. There are many rules that now govern how that water can be released.

<u>An Oil Company Perspective on the Importance of Water to the U.S. Petroleum Sector</u>

Speaker

- Curtis Stanley, Senior Principal Consultant for Soil and Groundwater Management, Shell Oil Company

Presentation

- The speaker discussed "The Stress Nexus," or an assessment of the linkages between energy production and water scarcity. Water is required at multiple stages of energy production, and competing demands for water (e.g., energy production, food production, and environmental protection) will continue to stress global water resources.
- Shell's global operations used 202 million cubic meters of water in 2010. Oil extraction also produces low-quality water (2.6 barrels of water per barrel of oil extracted) that requires treatment, recycling, and/or disposal.
- Shell's Control Framework guides the company's worldwide operations. It includes guidance for using and discharging water and managing risks related to soil and groundwater contamination.
- Shell's operating principles related to water use include:
    - Protect groundwater and reduce potable water use, as reasonably practicable.
    - Reduce the company's operational footprint.
    - Engage with local communities regarding socio-economic impacts related to operations.
- Examples of water use in Shell's operations include:
    - Downstream: an oil refinery that treats approximately 10 million gallons of effluent per day and consumes almost as much for cooling water.
    - Upstream: an oil and gas hydrofracking operation that uses 2 to 4 million gallons per well (with over 230 wells in 2011).
- Shell faces water challenges related to accounting, governance, reporting, and institutions:
    - Accounting challenges include data gaps, disagreement over how to define baseline, measurement issues, data specification issues (e.g., a lack of differentiation between consumption and withdrawal), and difficulties with accounting for considerations such as water quality and temporal use.
    - Governance challenges include fragmentation and conflict in regulations and among different government agencies that can lead to inefficiency in water management and allocation.
    - Reporting challenges exist due to inconsistent reporting requirements and difficulties in reporting detailed statistics.
    - Institutional challenges include imperfect water rights markets (laws can differ on a regional, state, and national basis), issues with price setting (average cost versus marginal cost), and ineffective policies on water reuse and recycling.
- What are economic considerations related to the value of water used by Shell?
    - Measuring the economic value of water is difficult because of competing demands and contributions of different sectors to the economy.
    - Water productivity should be considered over the lifetime of an energy asset – as water use may vary in different stages of development.

    - Water pricing needs to better reflect economic valuation principles; however, pricing decisions should remain a decision at the state or local level.
- From Shell's perspective, water management should be a local or regional issue driven by local user's needs. Improvements in efficiency and reductions in water footprints should be a goal, but within the reality of local and regional availability and use.

Discussion

- Discussion of this presentation was reserved for the plenary session.

5.B. Secondary Mega-Sector: Electricity and Public Water Supply

5.B.I. Electric Power

An Overview of the Water-Electricity Nexus in California

Speaker

- David Asti, Senior Manager, Corporate Environmental Policy, Southern California Edison

Presentation

- Southern California Edison (SCE) has been providing electric service in California for over a century and is one of the nation's largest electric utilities. It serves over 14 million people in a 50,000 square-mile area of central, coastal, and Southern California.
- California's power-generation assets include two nuclear power plants, hydropower in the Sierra Nevada region, fossil fuel plants along the coast, wind and solar power in the High Desert, and two areas of geothermal power production.
- Electricity challenges facing SCE include supply challenges (particularly during summer months), the California State Water Resources Control Board's once-through cooling policy, demand side management, transmission and distribution infrastructure, renewable portfolio standards (33 percent required by 2020), constraints on imported power, increasing energy demands, and the age and efficiency of existing base load plants.
- The regulatory framework for water in California includes California Water Boards, the state's 1969 Porter-Cologne Water Quality Control Act (the predecessor to the federal Clean Water Act in 1972), and regulations governing power plant cooling via inland waters.
- SCE and Southern California overall face water resource limitations, including state water policies that promote conservation and discourage the use of freshwater for power plant cooling, a semi-arid to arid climate (which increases water losses and cooling requirements), water resources located far from heavy demand areas, and contaminated groundwater basins.
- Typical water challenges for Southern California power plants include meeting requirements for wet cooling technologies (e.g., gas-fired combined-cycle power plants need between 4,000 and 6,000 acre-feet of water per year per 1,000 MW produced) and high temperatures that occur during peak demand months in the summer. Alternatives are limited as dry cooling

technologies are largely inefficient under high temperature conditions, and water availability limits the use of once-through cooling technology in inland areas.

- For a combined-cycle plant, water supply might be split between contaminated groundwater and reclaimed wastewater. Wastewater is treated prior to use, and wastewater disposal is strictly regulated.
- What water issues are expected to affect California in the future?
    - Increasing populations within California and in neighboring states will continue to stress water resources.
    - Salt water intrusion can jeopardize coastal water resources.
    - Transmission/distribution infrastructure must be upgraded in order to connect demand to sources of renewable energy, but people resist installation and upgrades of transmission lines near where they live.
    - Climate change is resulting in less snowpack, which affects the water cycle.
    - Other issues that pose challenges include dealing with nitrate management, "indirect potable reuse," and pharmaceuticals and personal care products (PPCPs).

Discussion

- Several fossil-fuel plants are going to retrofit with dry cooling (particularly near the coast, where thermal conditions are favorable). Inland plants will likely have to use wet or hybrid cooling, but they will pay for reclaimed water to be piped in. Independent power producers are doing some air cooling. Drawbacks to dry cooling include energy efficiency losses (about 10 percent), noise concerns, and space requirements.
- It is important to note the significant electricity requirements of water supply. Approximately 20 percent of electricity generated in California is used to pump/transport and heat water.

<u>Value of Water in Energy Production</u>

Speaker

- Vincent Tidwell, Distinguished Member of Technical Staff, Sandia National Laboratories, U.S. Department of Energy

Presentation

- Water is very important for thermoelectric power generation; over 89 percent of all power is generated from the steam cycle (which requires cooling), and another 10 percent is generated from hydropower resources.
- It's important to distinguish between water withdrawals and water consumption. While thermoelectric power needs account for approximately 42 percent of water withdrawals in the U.S. (in 2005), this sector accounted for only 3% of water consumption (as of 1995). In addition, there are large regional differences in the share of water withdrawn and consumed by the thermoelectric power sector.

- There is a need for integrated planning efforts that account for water management, transmission planning, and energy security.
- When thinking about how to meet water requirements for thermoelectric power, it is important to consider all potential water sources, including brackish water, wastewater, and water already appropriated for other uses that may be available for purchase. The speaker estimates that roughly half of power plants in the West could be converted to using low-quality water for cooling at a cost of $5 per MWh or less.

Discussion

- If moving from a once-through cooling system to an evaporative cooling system (due to downstream water quality concerns), one would expect to see increased water consumption; however, many older once-through systems are old and inefficient, so there may be less of an increase in consumption than expected. Historically, the Electric Power Research Institute has used a 3:1 ratio for evaporative cooling vs. once-through cooling.
- The analysis of the costs of converting to low-quality water for cooling does not account for the potential benefits of selling unused freshwater.
- The nuclear review committee is looking at air quality concerns of power plants that use seawater (and associated particulate emissions).
- To date use of alternative water sources in the northeast has required the user of alternative water sources to bear the full economic and regulatory risk. Since water used in closed loop systems is subject to evaporative loss (consumptive use) it is subject to both water and air permitting requirements. These permitting requirements impose costs beyond the capital and operating costs of the physical delivery and treatment systems themselves. Often, the user must pay both to purchase water from the source and to treat residual water returning to the source facility. Additional challenges include ensuring consistency in both the quality of the source water supply and the quantity of water necessary to meet the generating facility's operation needs.

5.B.II. Public Water Supply

Comments by Aurel M. Arndt - from the perspective of the Lehigh County Authority Chair and the AWWA Water Utility Council

Speaker

- Aurel Arndt, General Manager/Chief Financial Officer, Lehigh County Water Authority

Presentation

- The American Water Works Association has 50,000+ members, 5,000 volunteers, and an annual budget of $27 million.

- The Lehigh County Authority (LCA) serves more than 20,000 customers across 16 townships and provides wastewater service in 13 municipalities. The LCA has 40 employees and 2012 operating and capital budgets of more than $21 million and $24 million, respectively.
- Lehigh County is considered the "beverage capital" of the U.S. Several beverage-related businesses have decided to locate operations within this county. LCA believes these location decisions reflect the clean water supply available within the county.
- Utilities must confront issues such as protecting water supply sources, maintaining water quality, managing assets (infrastructure), determining rates and charges, accounting for legislative and regulatory requirements, and considering factors such as security, vulnerability, and emergency response protocols.
- Infrastructure replacement, in particular, will represent a challenge to water utilities.
    - AWWA published a report titled "Buried No Longer" that quantified what it will cost to replace buried infrastructure in water systems.
    - Not including treatment plants, tanks, wastewater systems, and pipelines, AWWA estimated that infrastructure replacement will require expenditures of over $1 trillion over the next 25 years.
    - While this infrastructure investment will generate jobs in the construction, engineering, and finance industries, it is also projected to increase user rates and costs.

Discussion

- AWWA has done studies of the incremental impact of discrete sources of water quality changes. The challenge is what baseline to use. Above a set point, one then defines measurable impacts that require public funds to treat. Water bodies have a certain amount of assimilative capacity that will help buffer what ultimately needs to be treated. It becomes a case-by-case evaluation of what surface waters are like. Lehigh County relies on a mix of surface and groundwater, with high-quality groundwater serving as a core resource.
- Going after better efficiencies in the market is a useful exercise, but just a short-term one based on affordability. Longer-term economics is how to think about how an economy will make more fundamental transformational change. People in the drinking water field are saying that entrenched big-grid systems come from fire service needs. If these fire service needs were handled separately, infrastructure requirements could be done through very different means. It is important to consider large-scale, transformational change to the way water resources are currently managed. Transformational change goes beyond markets, efficiencies, and technological improvements. Ultimately, there is a need to rethink things on a systems level.

<u>A Perspective from the Water Research Foundation</u>

Speaker

- Chris Rayburn, Director of Subscriber and Research Services, Water Research Foundation (WRF)

Presentation

- From the water utility perspective:
    - The economic importance of water is equivalent to the economic importance of a safe, affordable, and reliable water supply.
    - 100 years ago, the value of a safe, affordable water supply was clear as people were still dying from water-borne diseases and cities grew and prospered based on water's availability. Recognition of this drove massive investment in public water supply.
    - This public water supply investment was very successful in producing a safe, affordable, and reliable water supply; however, utilities are now victims of their own success. The sector has become so effective that its services have become "out of sight, out of mind."
    - When the time comes to reinvest in public water supply infrastructure, it is important to remind stakeholders of the importance of public water supply.
- WRF has conducted research on communicating information on the value of water to customers. Based on this research, the foundation has identified remaining information gaps for valuing public water supply. Utilities need better information on:
    - The willingness-to-pay of residential water customers. In particular, what aspects of the services that water suppliers provide are most valued?
    - Linkages between customer willingness-to-pay and trust in the utility to provide the services desired.
    - Straightforward models and tools for assessing the worth of public water supply relative to other uses of water.
    - Effective ways to communicate the value of public water supply.
    - Approaches for balancing infrastructure investment requirements with the goal of providing affordable service.

Discussion

- What USGS struggles with, when providing a picture of water use and availability, is a lack of any national database on the location and connectivity of the nation's water infrastructure. While such a resource could be very valuable, there are many challenges to gathering that information. Water is a very local resource, and there is active resistance to the notion of transporting water large distances (as is done with energy and telecommunications). Water infrastructure systems were not built to be interconnected systems; this connectivity has happened incidentally over time.
- It is difficult to get people to realize the value of water, above and beyond costs of service. A real education process is needed to convince people that it's worth paying more than current costs for water. In many parts of the world, there is a prevailing feeling that water should be free. Wastewater also has real monetary value. Maximizing recovery of resources in wastewater can be part of the solution to the drinking water problem in terms of availability and quality.
- Within the water utility industry, the notion that drinking water and wastewater are separate entities is rapidly crumbling. The nexus between these two water types is being increasingly acknowledged.

- Increasing water rates to meet infrastructure funding needs can be very challenging. Eighty percent of utility costs are fixed (e.g., infrastructure renewal, maintenance, etc.) and do not change based on water usage, but revenues are principally dependent upon water usage. It could be helpful to adjust water rates towards fixed-rates to match costs, but rate structures are heavily regulated.
- From a community perspective, the idea of bringing in more money to water systems has been around for a long time, but it isn't getting much traction. The reality for America's communities is that the price tag for infrastructure improvements is unbearable and Federal money is unavailable. It is important to consider the economic values and collateral benefits provided by public water supply. Communicating these benefits could generate cooperation and support among different parts of the community. For example, Gloucester, Massachusetts has a fishing industry that suffered from lack of wastewater treatment. If the link between wastewater treatment and benefits to the fishing industry were made clear, there would be more support for infrastructure renewal efforts.

5.C. Tertiary and Quaternary Mega-Sectors

5.C.I. Strategic Planning and Investment

A Review of Historical Water Price Trends

Speaker

- Steve Maxwell, Managing Director, TechKNOWLEDGEy Strategic Group

Presentation

- Water prices generally reflect neither the cost of water delivery nor the economic value of water. However, prices do represent an important driver for decisions on water use, management, and allocation. During the last few decades, demand for water has begun to outpace supply in certain parts of the country and in other parts of the world. Prices for raw and delivered water have begun to increase, and these rates of increase are likely to accelerate.
- What is known about the "water marketplace"?
    - Water markets frequently do not represent efficient markets in the classical sense where price information represents the value of the commodity. This is due to considerations such as information imbalances, the localness of water markets, utility regulations, and uncertainty surrounding individual water supplies.
    - Reliable data regarding prices and price trends for "raw" or delivered water are difficult to obtain and are usually only available for the last decade or so.
    - Gathering water price trend information is particularly difficult; this usually relies on anecdotal information.
- How are water markets reacting to changes in raw water prices?
    - International and domestic examples of raw water markets show increasing prices and, in turn, more efficient allocation of raw water resources. These examples include

southeastern Australia, parts of Colorado and Washington, and the corridor between Santa Fe and Albuquerque in New Mexico.
    - In the arid west, raw water transfers are increasingly occurring either between agricultural interests or between agricultural sellers and urban buyers.
- What is happening with delivered water prices?
    - Delivered water prices show steady growth at a slower and less volatile rate than raw water prices. This reflects the heavily regulated nature of delivered water pricing.
    - Prices fluctuate on a regional basis, partially reflecting hydrology and climate, but also reflecting political conditions and government subsidies.
    - Overall, data indicate that delivered water prices will continue to increase into the future. Studies have shown that over the last decade, delivered water prices have been increasing in the range of 5 percent to 10 percent per year; this annual growth rate is increasing.
- Water is emerging as a new investment class.
    - The increasing price trends for raw and delivered water have made water an emerging financial asset class and an attractive investment opportunity.
    - Water has grown at favorable rates when compared to traditional investment assets such as gold, commodities, stocks, and real estate.
- Conclusions:
    - As competition for water continues to grow on a national and global scale, water scarcity will be experienced in more and more regions. Over the longer term, it seems clear that delivered water prices must rise to reflect the growing competition for, and scarcity of, raw water supplies.
    - As prices begin to better reflect the value of water, we will begin to use water more efficiently.

Discussion

- Though studies comparing water rates in the U.S. to rates in other countries are often anecdotal and face data quality problems, in general it is true that Northern European rates are higher than rates in the U.S. Prices being paid in some countries (e.g., Germany, Denmark, and Sweden) are sometimes 3-5 times as much as average prices in the U.S. Furthermore, though exceptions exist, pricing has an inverse relationship to per-capita consumption around the world. The broader public will not change consumption patterns unless they receive a price signal.
- At a systems level, placing a higher priority on public use can have real costs. If municipal supply is protected during droughts, there is little incentive for users to pay more to improve water security. In Texas last year, during a drought, the first restrictions on water supply were applied to agricultural uses, while public use and electric power were protected at all costs. That kind of policy forces agriculture and industry to bear risk-related costs for droughts. It may be necessary to let municipal users to accept some risk in order to send the right signals and affect consumer behavior.

- In Western states, there is a trend away from prioritizing municipal water use above all other uses. Ten-twenty years ago, most policymakers agreed that low-value agricultural users should sell water rights to high-value water users. Farmers in Colorado were lining up to sell water rights because they were more valuable than the present value of their crops. At some point, this tendency to focus on agriculture as the source of water supply usage problems will be recognized as something of a simplistic/wrong assumption. Even if agricultural use of water is reduced, water will become a constraining factor on municipal growth in the future.
- Private utility bonds are one example of ways to encourage financial investment in water utilities. There will always be some disconnect between the supply of capital and demand in this sector as long as the same attitudes persist about bringing private capital to bear to solve public water supply problems. Greater emphasis on private-public partnerships could help close the gap.

5.C.II. Sustainable Water Resource Management

The Importance of Water to Sustainable Management of the Tennessee River System

Speaker

- Terry Cheek, Environmental Policy and Regulatory Affairs, Tennessee Valley Authority (TVA)

Presentation

- The TVA Act of 1933 created the TVA for the original purpose of focusing on navigation, flood control, power generation, and other benefits. TVA:
    - Is a U.S. corporation owned by the federal government;
    - Receives no appropriated funds;
    - Generates revenues from its power generation;
    - Has a service area of approximately 80,000 square-miles; and
    - Is responsible for operating and maintaining 49 dams that support 3 nuclear plants and 9 fossil-fuel plants.
- The Integrated Tennessee River System provides multiple benefits, including navigation, water supply, flood control, recreation opportunities, power generation, and water quality support. Management of the river system seeks to support and preserve these benefits.
- TVA conducted a Reservoir Operations Study in 2002-2004.
    - This study represented a review of TVA's operational policies to determine if changes were possible to produce greater public value.
    - Based on economic simulation and forecast modeling, policy revisions were implemented to balance between trade-offs among competing uses of water.
    - This economic simulation modeling relied on the use of input-output modeling that examined different mixes of water allocations between competing uses and subsequent economic impacts (i.e., GRP, jobs, earnings, and population).

    - TVA developed Reservoir Operating Guides as a tool for making decisions about moving water through and within the system.
    - With Reservoir Operating Guides in place, TVA uses a software program to optimize power generation along the river system.
    - Throughout this process, TVA manages data and information monitoring to inform management decisions.
- Data Gaps and Uncertainties
    - TVA has limited data on irrigation withdrawals, as these do not require permits.
    - Inter-basin transfer of water is a potential concern going forward (e.g., the Georgia and Alabama "water wars").
- Summary
    - TVA's water management policy recognizes and balances multiple benefits provided by the river system, including navigation, flood control, power generation, water quality support, water supply, and recreational opportunities. This water management policy reflects TVA's mission to produce the greatest public value.
    - TVA is always seeking to improve its water resources data and thus better inform its decision-making.

Discussion

- TVA and other power generating utilities face challenges related to the Endangered Species Act. Litigation from environmental advocacy groups is pressuring the Fish & Wildlife Service to move along on their candidate species list from 2010. In response to a petition, the Service is also reviewing an additional 374 aquatic species in the Southeast for possible listing as threatened or endangered.

<u>Importance of Groundwater to the U.S. Economy</u>

Speaker

- Venkatesh Uddameri, Professor of Civil & Environmental Engineering, Water Resources Center, Texas Tech University, Lubbock University-Kingsville

Presentation

- What are characteristics of groundwater resources?
    - Groundwater is a major source of freshwater.
    - It serves as the sole source of drinking water in many arid and semi-arid regions.
    - Groundwater is often viewed as a buffer against droughts.
    - The U.S. contains 62 principal groundwater aquifers, and many minor aquifer formations.
- How is groundwater used in the United States?
    - Approximately 26 percent of U.S. water withdrawals are from groundwater.

    - Groundwater use varies by states, with CA and TX representing the largest groundwater users by volume and NE and ID having the largest withdrawal per capita.
- While surface water is most used for thermoelectric needs, the largest uses of groundwater are irrigation and domestic use.
- Groundwater sustains flows in perennial streams and rivers. These flows in turn support ecological and recreational values.
- Groundwater produces economic impacts in the U.S. through:
    - Produced groundwater: Estimated value of $20.9 billion (as of 2004)
    - Groundwater-related infrastructure: Estimated value of $75 billion (as of 2003)
    - Groundwater-related businesses: Estimated value of $15.8 billion (as of 2010)
    - Groundwater-related manufacturing: Estimated value of $353 million (as of 2010)
- Groundwater supports U.S. businesses (in sectors such as drilling, environmental services, and remediation), community water systems, and scientist and engineering efforts throughout the U.S. (according to a National Ground Water Association study in 2012).
- What are major challenges for groundwater and aquifer sustainability?
    - Insufficient or improper planning and management can jeopardize sustainability.
    - Technological adaptations must be developed to improve water-use efficiency.
    - Climate impacts on aquifers can have severe economic consequences.
- Groundwater is a diffuse resource that is governed by multiple legal doctrines.
- There has been a shift towards participatory groundwater management that takes into consideration the needs of multiple stakeholders.
- Sustainable management of groundwater resources will require continuing efforts from a scientific and socio-economic perspective to develop methods to better understand and better manage the resource.

Discussion

- Discussion of this presentation was reserved for the plenary session.

<u>Perspective from the River Basin Commissions and the Association of Clean Water Administrators (ACWA)</u>

Speaker

- H. Carlton Haywood, Executive Director, Interstate Commission on the Potomac River Basin (ICPRB)

Presentation

- Sustainable water resource management is defined as meeting "the needs of the present generation without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).
- How is water economically important to the ICPRB?

    - ACWA members consistently work towards restoring and maintaining the quality of the nation's waters.
    - River basin commissions are dedicated to preserving water quality and quantity to meet multiple beneficial uses.
- What water-related information would help the ICPRB make better decisions?
    - Better measures of incremental progress toward restored water quality.
    - Costs and implications of implementing new water regulations.
    - Additional data on water metrics such as stream flow and precipitation, water use by source and economic sector, and water quality data to measure considerations such as impairments and restoration effectiveness.
    - Models to test water supply and demand under different scenarios of population growth, climate change, water use trends, and more.
- What can EPA or others do to help the ICPRB obtain this information?
    - Continue cooperation among the different levels of government towards improved methods and policies.
    - Promote regional flexibility.
    - Support and promote initiatives such as the USGS stream gage network, water quality monitoring, water model development, and improved access to data (both inter-agency databases and data standards).

Discussion

- Discussion of this presentation was reserved for the plenary session.

6. Plenary Discussion: Paths Forward

- It has been very useful to see ecosystem services coming out during these discussions. The discussion of the value of water is still a very human-centric measurement, and it is important to look at ecosystem services in their own right. Water is central to climate questions, and it is important to understand the role of water in sustaining life on Earth, beyond just ecosystem services. This relates to economic literature on the "global commons."
- When discussing the role of private capital in water supply, it is very important to look at what that would actually mean. In other fields, private capital entering a sector has not yielded expected results. Investments made for profits are not necessarily designed for public benefit. Studies need to be done before moving forward on integrating private investment.
- Many of the questions here point to the need for systems change, which depends on innovation. In Germany, many studies have been done that suggest that when practitioners and stakeholders are involved together, this generates a more effective economy of innovation.
- Economics can say more than just what is supposed to happen in idealized free markets. The question of environmental justice needs to be brought into the discussion of allocative efficiency. If a system assumes that allocative efficiency will automatically lead to equity, it will have sub-optimal outcomes. Economics offers valuable insights if the right questions are asked.
- Discussions of water's value must not neglect the importance of water quality.

- Focusing exclusively on market values of water can be problematic. This project should address the literature on non-use values.
- One representative of a water/sewer agency explained that his agency uses and re-uses water to a large extent and serves over 800,000 people. The agency purchased a brackish water and desalination plant over 15 years ago, and that has proven effective.
- If all a municipality has is a water district, it has to rely on somebody else for reclaimed water or desalination. Many challenges faced by utilities require joint ventures and a cooperative spirit.
- Part of why rate-payers are facing price increases is the natural cost of living, but another part is regulation. One agency conducted an analysis on its water rates and found that over 16 percent of the water rates represent the costs of regulations. Regulations may be necessary, but they add to the cost of service.
- A workshop attendee described his experience with the Endangered Species Act. Following ESA guidelines, Federal agencies restricted water supply in 2001 for agricultural uses in the Upper Klamath Lake region. Members of the community, particularly local farmers, were devastated because of the water supply restrictions. This represents a regulatory decision that affects the community; it was not related to hydrology or natural limits. Examples such as this illustrate the importance of considering real-life implications of decisions about water allocation and values.
- Case study examples are useful, and it would be interesting to consider more case study information in this effort.
- There are three things EPA can do to improve this effort:
    (1) Explore water footprinting. Though it does not necessarily represent the value of water, it holds valuable information about the interconnectedness of water and issues that are important to consider when estimating value.
    (2) Be precise about what information EPA is discussing (e.g., water withdrawals or water consumption).
    (3) Improve the consistency with which EPA considers ecosystem services. Rather than including ecosystem services for some uses (e.g., recreation, fishing) and not others, it is important to consider the full suite of ecosystem services.
- One attendee raised concerns about the focus and purpose of the workshop. There are many ways of analyzing issues economically. The overriding question for the EPA is what is it going to do with all this information? Is this going to have policy implications?
- There is an important opportunity here for integration and education. There are similar issues being dealt with across different sectors.
- It may be useful to consider more of a regional focus than a sectoral focus. EPA and other agencies can break down the sectoral "silos" in an effort to promote more integrated management at the regional level.
- The WateReuse Association represents an advocacy group to encourage water recycling. Several major corporations serve on the industrial use committee. This association has taken an active interest in managing water resources as a critical part of the industrial supply chain.
- An improved economic view and understanding of the value of water can help free up capital for water recycling and investment in other water initiatives and technology development.

- Venture capitalists are concerned about the huge problem of increasing water scarcity. "Aquapreneurs" meet regularly to discuss how to improve water management; however, start-ups and other efforts spearheaded by these aquapreneurs often die because water utilities take too long to decide whether they want to give the new ideas a try. The entrepreneurial water industry has real capital needs that are not being met in a timely and efficient manner. There is significant opportunity for EPA to add value by helping to better align utilities and capital markets.

7. Closing Remarks

- This particular effort is looking at just one piece of the question of what is the value of water. It intentionally focuses on market values as they are recognized in the economy today, while recognizing that this is a difficult pursuit.
- This effort is not designed to address current regulatory issues or to formulate new regulations and will not be analyzing holistic, systems-level questions that some attendees have raised.
- It is always important to caveat the results of this work, but it has generated an important set of information that will bear on how EPA and others focus future information-gathering initiatives. The report coming out of this effort will not be a policy document, but it will help others judge policy issues and questions about where public and private practitioners need better/more information on water resources.
- This effort serves as a building block that will contribute to a larger process that will take place in other forums as well.
- EPA will have a draft synthesis report available for the December symposium, with additional opportunities for comment afterwards.

Send comments to: importanceofwater@epa.gov