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TECHNICAL REPORT

Presenting Uncertainty About Climate Change to Water-Resource Managers

A Summary of Workshops with the Inland Empire Utilities Agency

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Summary

Water-resource managers have long strived to meet their goals of system reliability and environmental protection in the face of many uncertainties, including demographic and economic forecasts, intrinsic weather variability, and short-term climate change induced by El Niño and other naturally occurring cycles. Now water managers also face a new uncertainty—the potential for longer-term and more persistent climate change, which, in coming years, may significantly affect the availability of supply and patterns of water demand. Information about the future effects of climate change is deeply uncertain and likely to remain so for the foreseeable future. Thus, the scientific community is debating how to most usefully characterize this important yet uncertain information for decisionmakers.

RAND is conducting a large, multiyear study under a grant from the National Science Foundation (NSF) on climate-change decisionmaking under uncertainty (see ISE, 2007). As part of this project, we are working with water agencies in California to help them better understand how climate change might affect their systems and what actions, if any, they need to take to address this challenge. As a key component of this effort, RAND has conducted three workshops in cooperation with the Inland Empire Utilities Agency (IEUA), whose service area overlies southern California's Chino groundwater (GW) basin. In this report, we document our methods and observations to preserve an archive of the workshop process and provide a basis for refining our approach for future applications.

Purpose and Scope of IEUA Workshops

The IEUA region has already begun implementing many of the water-management strategies described in IEUA's *2005 Regional Urban Water Management Plan* (RUWMP) (IEUA, 2005). This plan includes a description of some of the analysis that California's Department of Water Resources (DWR) and Metropolitan Water District of Southern California (Metropolitan) conducted related to the effect of global climate change on imported water supplies available to IEUA. However, this information did not provide IEUA with a systematic assessment of the potential effects of future climate change on its service area and the actions that the region's cities and agencies might take to address these changes.

The purpose of the RAND-IEUA workshops was three-fold:

- Develop and exercise a new planning model for IEUA that enables consideration of the effects of large uncertainties on future system performance.

- Provide IEUA with state-of-the-art estimates of future climate change for its service area.
- Measure and assess decisionmakers' preferences among three different representations of key uncertainties and these uncertainties' effect on water-resource system performance.

Working in close consultation with IEUA staff and other water agencies, the project team developed a computer simulation model to estimate the performance of the IEUA RUWMP and potential modifications over a wide variety of scenarios that include different future climates as well as different levels of achievement of critical recycling and replenishment goals in the IEUA RUWMP. Over the course of three workshops (September 28, October 20, and November 3, 2006), the project team helped officials, technical staff, other water managers and planners, and other participants from the IEUA region to consider the significance of potential climate change relative to a few other key uncertainties and how planners might respond by reducing the vulnerability of supply disruptions under some scenarios. The RAND project team presented three different characterizations of uncertainty and administered surveys to workshop participants before, during, and after each of the workshops to record their views about the effectiveness and implications of the different presentations.

The first workshop characterized what is known about future climate change and then demonstrated differences in the performance of the IEUA RUWMP and variants (IEUA, 2005), based on assumptions that the current climate would continue into the future. In this first workshop, the RAND team presented climate and other uncertainties using a traditional scenario approach in which planners examined a small set of future conditions without assigning any likelihood or probability to their occurrence. In the second workshop, we presented state-of-the-art, probabilistic scenarios of climate change and then used these distributions to estimate the expected performance of the IEUA RUWMP and variants. Finally, in the third workshop, we presented a new approach, RDM, to develop policy-relevant scenarios, which were analytically derived from an extensive examination of many future conditions. We intended these scenarios to help IEUA consider ways in which it might augment its plans to reduce its vulnerability to potentially stressful future conditions.

Different Analyses of IEUA System Performance

The water-modeling analysis developed for this project not only offered the material for evaluating different presentations of uncertainty; it also provided useful information to IEUA and other regional water managers.

The traditional scenario analysis demonstrated that current plans would perform well if future climate were benign, that is, wetter than historic conditions, even with incomplete implementation of IEUA's recycling and replenishment goals. If the future climate were adverse, that is, drier and warmer than historic conditions, IEUA would need to meet its recycling and replenishment goals, as well as invest in more efficiency, and possibly allow more recycled-GW replenishment to ensure sufficient supply to meet demand. These traditional scenarios can provide a simple description of a range of future conditions relevant to IEUA. But such scenario analyses can also fall short of decisionmakers' needs because the choice of scenarios can appear arbitrary and the approach provides no systematic means to compare alternative policy choices.

The probability-weighted scenarios suggest that, if one believed the best-available probabilistic information about both future climate and the IEUA region's ability to meet the agency's recycling and replenishment goals, the IEUA RUWMP can ensure that the chance of a shortage over the next 25 years will not exceed 7 percent. Probabilistic scenarios can provide a concise ranking of the desirability of alternative IEUA plans but can lead to errors of omission in planning by downplaying the potential importance of possible futures that deviate from likeliest conditions. Further, effective use of probabilistic scenarios may require a wide range of stakeholders to agree on the validity of the distributions used in the analysis.

The policy-relevant scenarios identified two sets of conditions potentially most threatening to the success of the IEUA region's water-management plans—a Dry, Flashy, Low-Recycling scenario and a Wet, Effective-Recycling scenario. Under the Dry, Flashy, Low-Recycling scenario, the current plans fail to prevent frequent and significant shortages. Under the Wet, Effective-Recycling scenario, IEUA's current plan generates significantly more available water supply than the agency needs to meet demand. Such excess supply may indicate inappropriate overinvestment.[1] Additional efficiency and GW-management strategies improve performance under the Dry, Flashy, Low-Recycling scenario but may also generate excess surpluses if this adverse scenario does not come to pass. The analysis suggested that, if managers from the IEUA region believe that future conditions are more than 25 percent likely to be consistent with the Dry, Flashy, Low-Recycling scenario, investments in greater efficiency and more use of recycled water for GW replenishment than what is specified by the IEUA RUWMP would be prudent.

Policy-relevant scenarios are designed to provide concise descriptions of a plan's potential vulnerabilities and help suggest modified or new strategies that can reduce those vulnerabilities. However, generating such scenarios can prove a nontrivial exercise and may prove more complicated to explain to decisionmakers and stakeholders than the more familiar scenario and probabilistic scenario approaches. In addition, creating policy-relevant scenarios requires several explicit and potential subjective judgments on the part of decisionmakers and analysts (e.g., what level of adverse performance qualifies as a vulnerability?) that may influence the results.

As one of their key purposes, the workshops aimed to examine the extent to which IEUA decisionmakers would find useful each of these three different approaches to characterizing uncertainty.

Workshop Results

Before, during, and after each workshop, the RAND team administered surveys to measure how the presentations and discussions of the different characterizations of uncertainty influenced participants' views.

Attitudes About Climate Change

Participants whose opinions were measured after the third workshop were less likely to see climate change as a slow process and to feel that they would have warning and likelier to feel that

[1] There are likely to be other benefits from excess supply not explicitly examined in this study. This study used oversupply as a proxy for investment costs that will be handled more explicitly in later phases of the analysis.

climate change could be upon them before they were aware of it than were participants whose opinions were measured before the first workshop. This shift in opinion appears consistent with the climate science presented during the sessions.

Comparison Among Presentations of Uncertainties

Participants reported the traditional scenario approach the easiest to understand and to explain to decisionmakers. They found that it conveyed information in the most objective way but, compared to the other approaches, provided less of the information needed for planning in general and specifically to evaluate the plans of the IEUA region. The policy-relevant scenario approach, derived from RDM, was rated as providing the most valuable information for planning, comparing climate-related risks, and making choices among plans but least objective and least easy to understand and explain.

Attitudes About Responsibility for Long-Term Planning

Not surprisingly, participants reported feeling significantly more responsible for the immediate future (five to 10 years) than they did for the long-term future (50 to 250 years). Interestingly, this relationship did not change from survey to survey until after the third workshop, at which point participants rated themselves as slightly less responsible for the long-term future than did participants in the first workshop. In part, this small shift, if it was indeed due to anything other than noise in the data, may have been influenced by the focus in the workshops on a relatively short, 30-year time interval. Alternatively, the workshop results suggested that the IEUA region could become significantly more robust against a wide range of future climate-change scenarios by successfully achieving the agency's challenging near-term goal for an almost three-fold increase in its use of recycled water. Given a not-unreasonable expectation that the biggest risks to public acceptance of a new recycling program would come in its early years, an appropriate response to the information presented in the workshop might be to increase one's focus on the near term.

Attitudes About Modeling

Participants came to the workshop with a belief that quantitative modeling was useful and an eagerness to see what we could present. Exposure to the workshops did not shake this positive belief. We found some support for the hypothesis that modeling (including the approaches to scenario generation shown in these workshops) tended to make managers less confident about their management ability in the face of uncertainty, more willing to take risks, use models, and make adaptive changes; less willing to rely on their instincts; and less inclined to see situations as unique. Thus, these measures provide weak support for the proposition that the use of modeling can improve the management of risk and uncertainty.

Preferences for Actions the IEUA Region Might Take

When asked to rate a series of actions that the IEUA region might take, participants gave the highest marks to actions that the region's agency already has under way and that are key to their existing plans. Next in priority were measures related to new construction, increasing GW recharge, construction of new transmission lines for recycled water, construction of new GW-desalting plants, enacting tighter appliance standards, and improving the permeability of the basin to increase GW recharge. Taking more intrusive measures was viewed with less enthusiasm, and measures, such as increasing water rates to reduce demand, introducing recy-

cled water into the water supply, and slowing new development through zoning changes, were lowest priority. Ratings changed only slightly over the course of the workshops, and the rank ordering remained more or less the same.