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# Addressing Climate Change in Local Water Agency Plans

Demonstrating a Simplified Robust Decision  
Making Approach in the California Sierra  
Foothills

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# Summary

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## Introduction

Water agencies have always faced uncertainty when developing programmatic plans and constructing infrastructure. Today’s water agencies use computer models of their systems to calculate future water supply, demand, and infrastructure needs. Mindful of the effects that new investments have on the water rates they must charge their customers, they seek solutions that will ensure reliable future supplies of water but that are not overly costly.

This study describes an analytic and objective approach for (1) evaluating how plausible changes in the climate and other uncertain factors would impact an agency’s long-term plans and (2) understanding the key tradeoffs among adaptation options. This approach, called Robust Decision Making (RDM), is designed to use estimates about future climatic and hydrologic conditions without committing to the veracity of any particular estimate. Instead, it supports a systematic exploration of plausible climate effects and impacts, identifies vulnerabilities—or the specific scenario conditions that would lead agencies plans to perform unacceptably, provides information to compare options that could alleviate these vulnerabilities, and ultimately defines a robust strategy—one that will perform well over a wide range of plausible future conditions. Importantly, it supports an analysis of uncertainties related to climate change alongside other factors that may be just as important to the success of the long-term plans.

RDM is increasingly being used to support long-term water planning activities. The U.S. Bureau of Reclamation and the Metropolitan Water District of Southern California, for example, have recently completed extensive studies that use RDM to evaluate the vulnerabilities and adaptation options for the Colorado River Basin and the Metropolitan service area, respectively (Bureau of Reclamation, 2012; Groves et al., 2013; Groves et al., submitted). These applications used sophisticated simulation models to evaluate management strategies across thousands of plausible future conditions, employed statistical analyses to identify and define key vulnerabilities, and in the case of the Colorado River Basin, evaluated tradeoffs among different portfolios of water management strategies.

This study, in contrast, demonstrates a relatively simple application of RDM for the El Dorado Irrigation District (EID)—a local water agency in the foothills of California’s Sierra Nevada Mountains.<sup>1</sup> The analysis is deliberately designed to be straightforward so that it can be replicated by other local water agencies. It illustrates how agencies can use climate data that are readily available and develop simple assumptions to explore uncertainty that is often ignored in

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<sup>1</sup> The study team included researchers from RAND Corporation and the Stockholm Environment Institute (SEI). Staff from EID provided data, advice, and reviews.

long-term planning exercises—in this case, future demand and the availability of a critical new supply. Lastly, it illustrates an RDM analysis through a series of planning questions that will resonate with water agencies and can be adapted for other applications. While this analysis uses a water management simulation model to quantitatively assess outcomes in about 50 different future scenarios, many of the RDM concepts could be used to inform less quantitative assessments.

EID faces many of the same challenges facing other water utilities in the Western United States—increasing population, limited new local supply opportunities, and potential reductions in and altered availability of supplies due to climate change. EID has several opportunities for addressing these challenges. Its recently developed Master Plan (El Dorado Irrigation District, 2013) identifies a number of different strategies including developing additional programs that increase the efficiency of water use, acquiring new water supplies through arrangements with other agencies (e.g., the Sacramento Municipal Utility District [SMUD]), and constructing new reservoir facilities.

## Use of Robust Decision Making to Evaluate Vulnerabilities and Adaptation Strategies

This study uses RDM to analyze the potential vulnerabilities of EID’s current water management plan to future climate, demographic growth, and availability of external new supplies. Table S-1 summarizes the key elements of the RDM analysis of the EID system—key uncertainties, management strategies, performance metrics, and systems models. This study uses a water-planning model developed in the Water Evaluation And Planning (WEAP) modeling environment. The model evaluates water management conditions using climate drivers (i.e., temperature and precipitation), rather than historical stream flows, and is thus ideally suited for evaluating the effects of climate change on the management system. The model was calibrated to project future supply and demand levels that are consistent with the assumptions used by EID for their recently completed master planning process. This study, however, explores a broader set of scenarios to encompass additional uncertainties and focuses on different performance metrics and management strategies than the Master Plan.<sup>2</sup>

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<sup>2</sup> Some of the differences between the assumptions used in the Master Plan analysis and this study arise from the different timing of the two efforts.

**Table S-1: Summary of Uncertainties, Policy Levers, Relationships, and Metrics (XLRM Matrix)**

<b>Uncertainties or Scenario Factors (X)</b>	<b>Management Strategies or Levers (L)</b>
Future climate conditions Demographics Availability of new supplies	2010 Urban Water Management Plan Additional Management Strategies <ul style="list-style-type: none"> <li>• Additional urban water use efficiency</li> <li>• New reservoir</li> </ul>
<b>Relationships or Systems Model (R)</b>	<b>Performance Metrics (M)</b>
Water planning model of EID	Unmet Water Demand and Reliability Notional Strategy Costs

## Results

This study addresses several key long-term planning questions using the RDM iterative methodology.

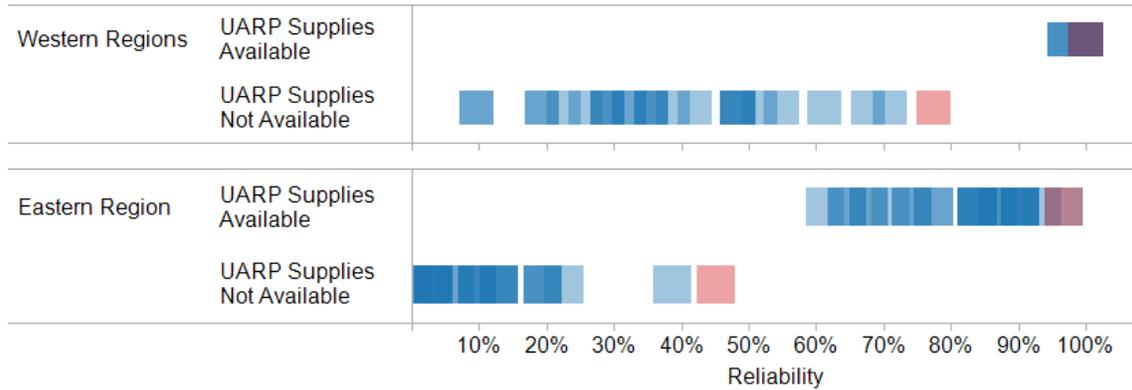
### *How Reliable Is EID’s Current Plan Under a Wide Range of Plausible Assumptions About the Future?*

We simulated EID’s current plan under historical climate conditions and with access to new supplies from the Upper American River Project (UARP) in 2020. We found that under these baseline-planning assumptions, EID’s current plan is 100-percent reliable in EID’s Western Regions (i.e., El Dorado Hills and Western Region) and 94-percent reliable in the EID’s Eastern Region. The Eastern Region is less reliable as it does not have access to many of the supplies available in the west. Reliability in this study is defined as the percentage of years in which demand is largely met. The thresholds for a year to be considered reliable are 85 percent of demand for the Western Regions and 90 percent for the Eastern Region.

We next explored how well EID’s current plan would perform under different but plausible assumptions about future climate, demand growth rates, and the availability of UARP supplies. We found that reliability for both regions would be substantially degraded.

Figure S-1 shows the reliability for the Western Regions and Eastern Region for each future, separated by the UARP supply assumption. Each square represents reliability results for one of the 52 simulation results. Results for the baseline growth scenario are shown in light red. Overlapping results appear darker in the figure. Without UARP supplies available (bottom rows for each region), reliability in both regions varies significantly across the climate and demand scenarios. If UARP supplies are not available, the most stressing scenario reduces reliability in the Western Regions to about 10 percent, and to 0 percent for the Eastern Region. The most favorable climate and demand assumptions, however, lead reliability to exceed 75 percent and 45 percent for the Western Regions and Eastern Region, respectively, for the given thresholds. The reliability of supply in the Eastern Region with UARP supplies is also sensitive to climate and growth assumptions—reliability ranges between about 65 percent and 95 percent.

**Figure S-1: Reliability for Each Future Disaggregated by Region and UARP Availability Scenario**



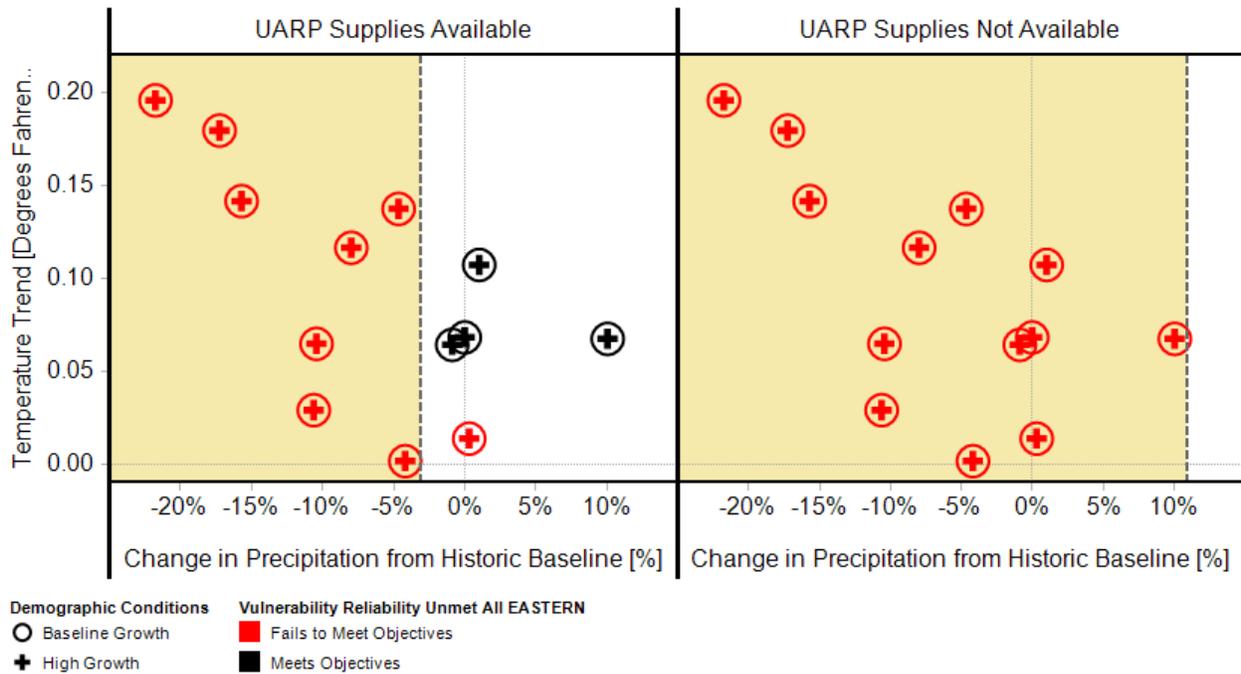
NOTES: Each square represents reliability results for one of the 52 futures evaluated. Results for the baseline assumptions (historical climate, baseline growth) are indicated in light red.

***Under What Conditions Is EID’s Current Plan Most Vulnerable?***

In order to focus the analysis on outcomes that would not meet EID broad planning goals, we defined a vulnerability threshold of 90 percent—reliability outcomes less than this threshold for either region indicate a vulnerability. Through iteration, we identify two sets of conditions—one for the Western Regions and one for the Eastern Region—that lead to a high number of vulnerable cases and relatively few non-vulnerable cases. For the Western Regions, 26 of the 52 futures evaluated are vulnerable, and they all correspond to futures in which there is no new UARP supply. These conditions are called “UARP Supplies Not Available” and describe all the vulnerable outcomes (100-percent coverage) and none of the non-vulnerable outcomes (100-percent density).

The vulnerable conditions are more nuanced for the Eastern Region and include all futures in which UARP supplies are not available. For those futures in which UARP supplies are available, however, the vulnerable conditions include futures in which precipitation declines by more than 3 percent over the historical average of 1,070 millimeters (mm)/year. The assumptions about future growth in the region do not distinguish between scenarios that are vulnerable and those that are not. We call these conditions “UARP Supplies Not Available or Drying Climate.” They describe 96 percent of the vulnerable outcomes and include no non-vulnerable outcomes. Figure S-2 shows the vulnerable conditions graphically in terms of precipitation and temperature (horizontal and vertical axes), with and without UARP supply (left and right graphs), and demographic growth rates (symbols). Results colored red are those that are vulnerable. The shaded region corresponds to the definition of the vulnerable conditions.

**Figure S-2: “UARP Supplies Not Available or Drying Climate” Vulnerable Conditions for Eastern Region**



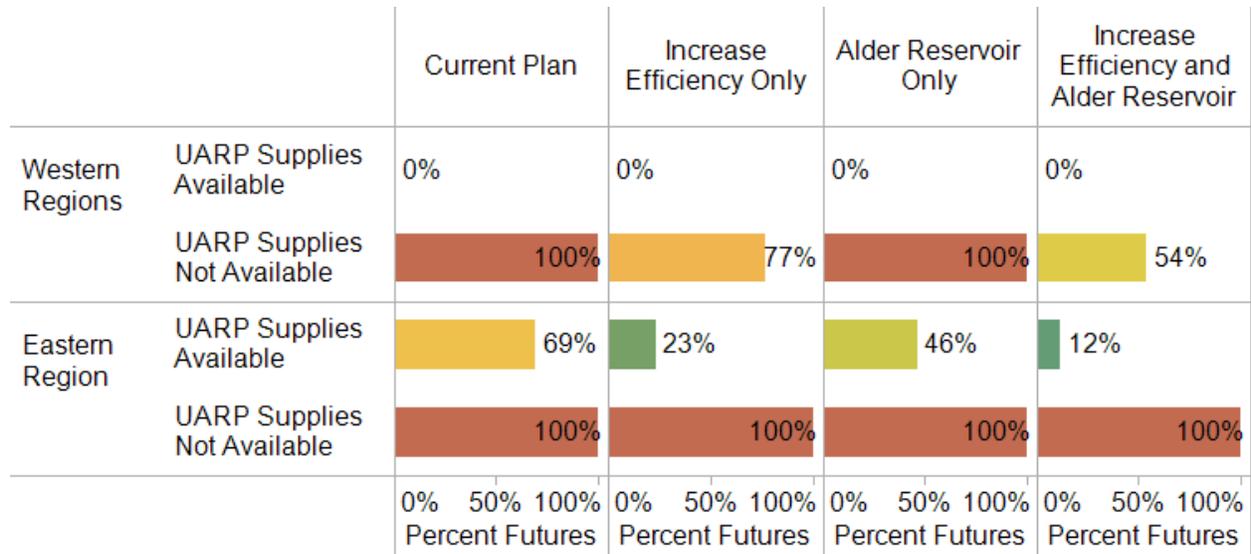
In summary, the vulnerability analysis determined that the Western Regions are primarily vulnerable to the availability of supplies from UARP, regardless of climate and growth rates. For the East, vulnerable outcomes occur even with UARP supply available; these outcomes are associated with conditions that are only slightly drier than those in the historical record. These results suggest that climate uncertainty is more critical to determining the success of EID’s plans than the assumptions about demographic growth.

***How Can EID’s Vulnerabilities Be Reduced Through Additional Management Options?***

Following the iterative RDM steps, we reevaluated EID’s system under the 52 scenarios three more times—once for each of three strategies. We found that increasing efficiency reduces vulnerabilities in the Western Regions when UARP supplies are not available and significantly reduces vulnerabilities in the Eastern Region when UARP supplies are available (Figure S-3). Constructing a new reservoir (Alder Reservoir) does not reduce the vulnerabilities in the Western Regions, but in the Eastern Region it does reduce vulnerabilities when UARP supplies are available from 69 percent to 46 percent of futures. Increasing efficiency and constructing the Alder Reservoir provide reductions in vulnerability for both the Western Regions when UARP supplies are not available and for the Eastern Region when UARP supplies are available. Note that while increasing efficiency and constructing the Alder Reservoir benefit the Eastern Region when UARP supplies are not available, the Eastern Region is still vulnerable in 100 percent of the scenarios evaluated. This indicates that none of the additional strategies evaluated in this

study improve reliability enough in the Eastern Region under futures in which the UARP supplies are not available.

**Figure S-3: Percentage of Vulnerable Scenarios by Region, by UARP Scenario, and by Strategy**



### *What Are the Key Tradeoffs and How Can They Inform Decisions?*

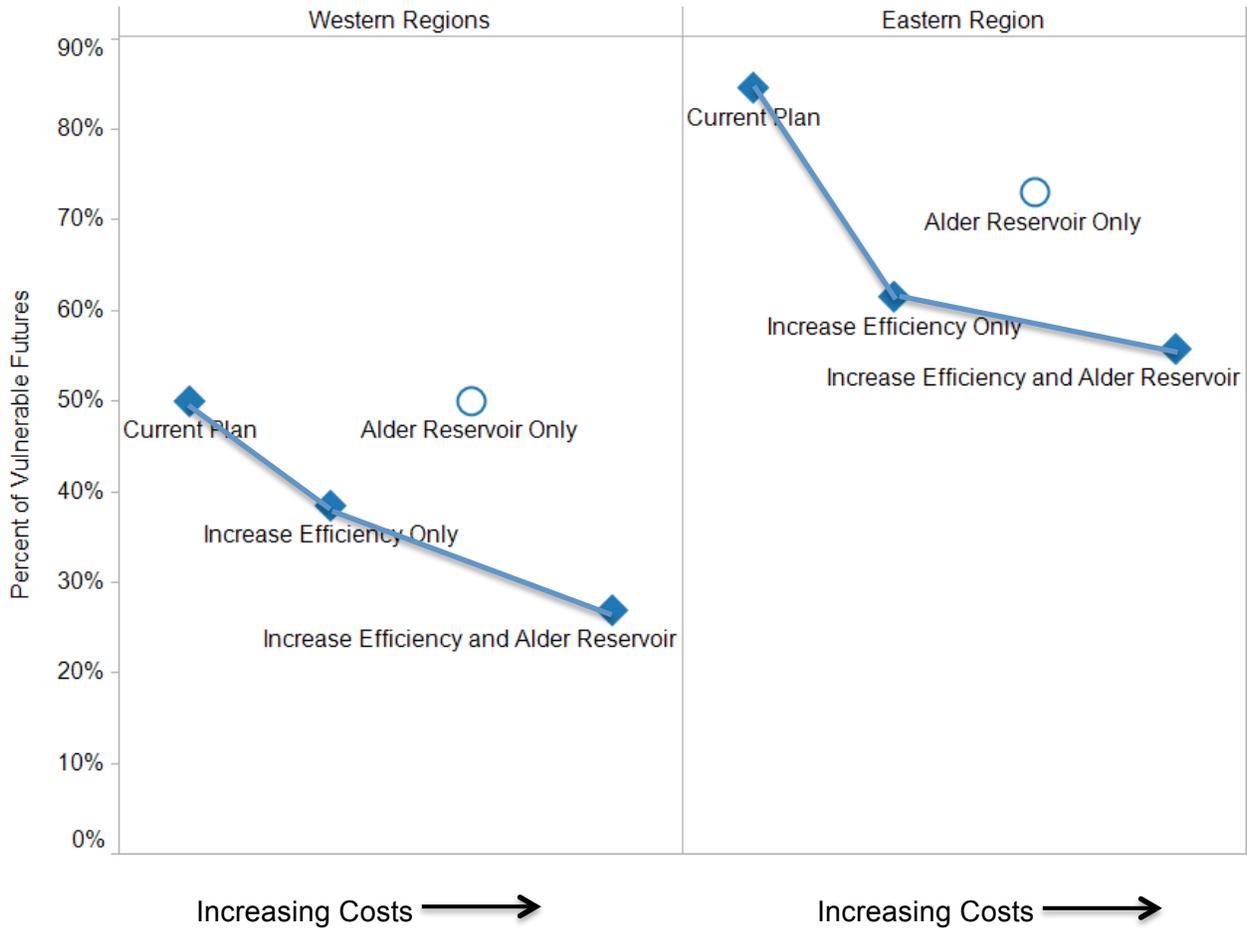
Decision makers never have perfect foresight; they have to consider the full range of possible conditions that they may face and the tradeoffs among strategies. In this case, the tradeoffs are simplified to be vulnerabilities in the Western and Eastern Regions versus cost of implementing additional options. Figure S-4 plots each strategy by the percentage of futures that are vulnerable (vertical axis) and the ranked cost (horizontal axis).<sup>3</sup> The *Construct Alder Reservoir Only* strategy entails more effort and costs and reduces vulnerability less than the *Increase Efficiency Only* strategy; hence it is a *dominated* strategy.<sup>4</sup> The other strategies form a tradeoff curve between effort and percentage of futures that are vulnerable, with the current plan requiring the least effort but leading to the greatest percentage of futures vulnerable in both regions.

In the final step of the RDM analysis, we combine the empirically derived information about vulnerabilities and the conditions that lead to them with subjective information about how likely are the conditions to which the system is vulnerable. Together this information provides guidance on how much to invest to reduce vulnerabilities.

<sup>3</sup> This study considered only ranked costs since actual costs for increasing efficiency were not available.

<sup>4</sup> A *dominated* strategy is one that is inferior to others in all dimensions under consideration—in this case, reduction in vulnerability and cost.

**Figure S-4: Tradeoffs Between Ranked Costs and Percentage of Vulnerable Futures**



NOTES: Strategies with a diamond shape are those on the frontier of the cost and vulnerability tradeoff curve. Strategies with a circular shape are dominated by alternative strategies. The horizontal axis indicates ranking of costs only.

## Conclusion

This study illustrates how RDM can be used in water agency planning to consider climate and other deep uncertainties. In this case, the study considers uncertainty about future climate and hydrologic conditions, urban growth rates, and success in developing a new, large water supply. The approach can be easily expanded to consider many more uncertainties of concern. While the results are largely demonstrative, they confirm the importance of the UARP supplies that EID is seeking for supply augmentation. This new supply alone, however, will not ensure robustness to climate change in the Eastern Region. Increasing efficiency could be an important hedge.