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Managing California's Water: Insights from Interviews with Water Policy Experts

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Author:
Null, Sarah E., Utah State University
Bartolomeo, Eleanor, University of California, Davis
Lund, Jay R., University of California, Davis
Hanak, Ellen, Public Policy Institute of California

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Author Bio:
Department of Watershed SciencesAssistant Professor

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Managing California's Water: Insights from Interviews with Water Policy Experts

Sarah E. Null [1†], Eleanor Bartolomeo [2], Jay R. Lund [2,3], and Ellen Hanak [4]

ABSTRACT

This paper presents insights from interviews with over 100 California water policy experts, who answered open-ended questions regarding California's long-term water policy challenges and potential solutions. Interviews were conducted in the spring and summer of 2010, and interviewees were selected from a range of sectors and regions within California. Top long-term policy problems cited include management of the Sacramento–San Joaquin Delta, dysfunctional institutions and water governance, unsustainable water supplies and flood management, poor environmental protection, and problems with water rights and valuing water. In addition to a range of specific management solutions, respondents emphasized the importance of public education, incentivized cooperation, more holistic water management, local innovation, and removal of regulatory obstacles as primary solutions to California's long-term water challenges. There was little emphasis on new surface storage projects, except from politicians. Other respondents preferred local and regional approaches to improve water supply, such as conservation, groundwater banking, recycling, or stormwater management. Despite differences in opinion on the problems with implementation of the Endangered Species Act, there was broad agreement that environmental management approaches need to shift away from single-species, piecemeal approaches toward ecosystem-based, multi-species approaches.

KEY WORDS

Water policy, water management, California, interview.

INTRODUCTION

As part of a project that assessed the challenges and potential solutions to California's water problems (Hanak and others 2011), we conducted qualitative interviews with over 100 leading water policy analysts, researchers, politicians, lawyers, and managers in the first half of 2010. We asked survey participants to share their thoughts on long-term water management challenges and policy solutions by responding to five open-ended questions (Table 1). This paper summarizes the results of these interviews to assess how much agreement exists among water policy experts about what is going on (and going wrong) with water policy across regions and sectors and to gain insights on current problems, promising solu-

† Corresponding author: *sarah.null@usu.edu*
1 Department of Watershed Sciences, Utah State University
2 Department of Civil and Environmental Engineering, University of California, Davis
3 Center for Watershed Sciences, University of California, Davis
4 Public Policy Institute of California

Table 1 Interview questions

1. What do you see as the five most important long-term water policy issues for California?
2. If you could list five state policy actions that would be useful for the long term, what would they be, in rough prioritized order?
3. Similarly, what should be the top five federal policy actions, in rough prioritized order?
4. What are the most significant challenges that will need to be overcome to accomplish the major water policy actions you have identified?
5. How might these challenges or obstacles be overcome?

tions, and novel ideas. The interviews occurred during a period when a multi-year drought, a major economic recession, and a series of court cases regarding endangered species and water supply cutbacks from the pumps at the southern end of the Sacramento–San Joaquin Delta were likely to have influenced the thinking of many respondents.[1]

Many books and journal articles have been devoted to California's water problems and solutions (for example, Pisani 1984; Reisner 1986; Kelley 1989; Hundley 1992, 2001; Carle 2000; Jury and Vaux 2005; Lund and others 2010; Hanak and others 2011). The literature makes clear that problems raised by our survey respondents are not new: Bay–Delta problems, dysfunctional water institutions, unsustainable water supply, and unmanaged groundwater have been known problems for decades. Our objectives here were to know how water experts perceive these problems, whether some problems need to be resolved before others can be addressed, and whether views diverge for experts employed by different water sectors or organization type. When possible, we compare problems discussed in interviews with the scientific and policy literature to better contextualize problems, highlight how water experts perceive problems and solutions, examine whether there is a disconnect between the literature and the views of leading water experts, and explore the extent to which these experts have novel, innovative, or creative ideas that are not reaching a wider audience.

For researchers, policy makers, and practitioners, this study illustrates the application of a qualitative method for improving understanding of complex and controversial topics, and highlights some water policy challenges in California. Loosely-structured, open-ended interviews are particularly useful for gaining insight on complex or technical water management challenges. The intent for this project was qualitative and applied—to share the impressions, concerns, and promising solutions of water experts with the broader water management community. This approach is consistent with methods for interview studies described by Bailey (1994) to obtain clear respondent statements to express and share ideas. Ferreira and others (2005) used a similar approach to interview 89 individuals on the use and development of the CalSim II model in California, using open-ended questions to solicit the range of thoughts and suggestions of technical experts in the state. Connick and Innes (2003) also used an open-ended interview approach to better understand collaborative policy-making processes in California water management for the San Francisco Estuary Project, the CALFED Bay Delta Program, and the Sacramento Area Water Forum.

Understanding the opinions of water managers and leaders is important because groups of experts are not homogenous (Weible 2008). Policy decisions are made by groups of individuals, so it helps to understand what they think (Sabatier and Jenkins–Smith 1993). This is especially valid for individuals who are leaders in their fields, whose opinions are likely to carry weight among colleagues, political leaders, and the public. The views of the experts interviewed for this paper underscore where little consensus exists within and between groups that represent different water sectors or occupations, and where differences in beliefs may hinder effective decisionmaking. Understanding how water experts think may highlight similar groups that can collaborate, as well as groups with opposing views that must negotiate to resolve differences. Over time this type of information could improve learning, change beliefs of individuals, and ultimately foster policy change (Weible 2008).

1 For background on the problems in the Delta, see Lund and others (2010).

METHODS

We used an expert sampling approach to choose respondents for this survey. We identified most of the experts in the sample, although occasionally, additional respondents were referred by interviewees. We chose water experts based on their experience and broad or deep perspectives on water resource policy (see Appendix A for a list of interview respondents). The pool of respondents broadly represents the state's geographical diversity as well as the range of economic sectors using water, and the types of employers of water experts, so that water problems and/or promising solutions for one geographical area or water sector are not over-emphasized. To encourage an open and honest dialogue, respondents were informed in advance that answers would not be attributed to specific individuals.

Time and scheduling considerations limited the number of interviews, so the sample is neither exhaustive nor statistically representative of various groups involved in California water policy. We interviewed 113 individuals; some interviews were conducted in groups, however, to facilitate discussion of potential solutions. For interviews conducted in groups (consisting of two to five individuals), it was not possible to keep track of individual responses to all questions. We provide a rough estimate of group responses by counting them twice; this understates responses when there was broader agreement among members of a larger group. This method of counting groups results in 94 responses.

Because we hypothesized that respondents' opinions might vary with their occupation or type of employer, we separated responses into seven "water sectors" (Table 2). "Academics" includes university faculty, researchers, and agency lead scientists. "Agricultural" and "urban water agency" respondent groups include employees of local water districts and water users associations as well as attorneys and consultants who represent these entities. "Politicians and staff" includes elected officials and their staff who specialize in water resources. The "operations and flood control" group includes state and federal agency staff and consultants involved in water project operations or flood response. The "regulatory and environmental" category includes staff of state and federal regulatory agencies, affiliates of non-profit environmental organizations and private sector lawyers and consultants who work on environmental issues. The "other" category combines groups that were very small, such as media or business interests, and group interviews in which respondents included members of different sectors.

We provide the percentage of responses for both the sample as a whole and the seven water sector categories to show how experts from different sectors perceive problems (Table 3) and potential solutions (Table 5). We also analyze whether response differs based on water sector categories using Pearson's chi-quared tests (Tables 4 and 6). Chi-squared tests analyze goodness of fit for categorical data and are routinely used for open-ended survey data and relatively small sample sizes (Vaughan 2001). They show whether observed distributions result from chance or whether relationships exist between category and response. We wanted to know the extent to which response differed by sector to see the concerns of different groups, if particular groups think about problems and solutions differently than others, and which problems and solutions have general consensus among groups. This type of analysis can help gauge where there is widespread support for solutions, clarify which groups uniquely do not view some aspects of water management as problems, and show whether there are similarities between some sectors that may facilitate collaboration.

Chi-squared tests determine probability values (p-values) that show whether a response is independent of respondent category. For Tables 4 and 6, we bolded p-values below 0.05, indicating that the response is dependent on water sector. (A critical value of 0.05 indicates that the probability of obtaining, by chance alone, a relationship between respondent category and response when in reality none exists is less than 5%). We also provide the observed and expected number of respondents who discuss each major problem (Table 4) and solution (Table 6) by water sector. Although we sought to have a large-enough sample size to discern variation in views across sectors, the number of responses on some issues is too

Table 2 Number of respondents by water sector

Water sector	Number of respondents	Number of group interviews
Academics	16	1
Agricultural water agency	13	2
Operations and flood control	14	0
Politician and staff	10	0
Regulatory and environmental	18	1
Urban water agency	16	2
Other	7	2
Total	94	8

NOTE: See text for group definitions. For interviews conducted in groups (consisting of two to five individuals), it was not possible to keep track of individual responses to all questions. We provide a rough estimate of group responses by counting them twice; this understates responses when there was broader agreement among members of a larger group. This method of counting groups results in a lower overall tally of responses than the total number of individuals interviewed (see Appendix A).

small to allow for reliable statistical inference.[2] In Tables 4 and 6, the responses for which this poses a potential problem are presented in italics. We omit the 'other' category in chi-squared tests because the mixed nature of group membership makes it difficult to interpret views by affiliation; the small sample size also made statistical results for this group suspect.

Because interview questions were open-ended, results of this study indicate which problems and solutions are foremost in people's minds; they do not indicate the degree of general support for any particular statement or action.[3] For example, when we state that

2 When more than 20% of the respondent groups have fewer than five expected responses on an issue area, the chi-squared results are suspect (Vaughn 2001).

3 Acquiring this type of information would have required us to ask respondents to provide feedback on specific issues and options. We opted not to include such closed-form questions to keep the discussions more free-ranging.

Table 3 Long-term water problems and policy actions (% of respondents)

Problem	Academics (16)	Agricultural Agency (13)	Operations / Flood (14)	Politicians / Staff (10)	Regulatory / Environmental (18)	Urban Agency (16)	Other (7)	Total (94)
The Delta	50	62	57	**90**	56	50	43	57
Dysfunctional institutions	25	**77**	**86**	60	39	**75**	29	56
Unsustainable water supply	**63**	38	50	70	22	63	29	48
Unmanaged groundwater	56	31	36	80	44	19	43	43
Climate change	31	8	71	60	**67**	25	14	41
Endangered Species Act-related problems	31	54	21	30	61	44	14	39
Insufficient water use efficiency	44	46	36	40	33	38	14	37
Regulatory problems	13	38	21	40	61	50	29	37
Water rights system	31	31	14	40	50	38	29	34
Water quality	56	8	29	20	28	50	43	34
Deteriorating aquatic ecosystems	44	15	21	20	50	—	**57**	29
Sporadic funding sources	31	15	50	30	11	19	43	27
Flood risk	25	15	71	20	17	6	43	27
Water transfer problems	19	46	7	10	28	38	14	24
Undervaluing water	44	—	14	20	28	19	14	21

NOTE: For each respondent, the Table includes up to 15 answers (up to five answers each for questions 1 through 3, see Table 1). Issues raised under all three questions are expressed in terms of the policy problem they reflect. Responses noted in group interviews were counted twice. Bold values indicate the highest percentage for each category of respondents.

Table 4 Number of observed (O) and expected (E) respondents that discuss problems in each water sector category sector category. Bold values indicate statistically significant differences between water sectors ($n = 87$, df = 5); test may be invalid for responses highlighted with italics because of small cell sizes[a].

Problem		Academics (16)	Agricultural Agency (13)	Operations / Flood (14)	Politicians / Staff (10)	Regulatory / Environmental (18)	Urban Agency (16)	Chi-square	*p*-value
The Delta	O (E)	8 (9.4)	8 (7.6)	8 (8.2)	9 (5.9)	10 (10.6)	8 (9.4)	5.170	0.396
Dysfunctional Institutions	O (E)	4 (9.4)	10 (7.6)	12 (8.2)	6 (5.9)	7 (10.6)	12 (9.4)	**18.150**	**0.003**
Unsustainable Water Supply	O (E)	10 (7.9)	5 (6.4)	7 (6.9)	7 (4.9)	4 (8.9)	10 (7.9)	9.840	0.080
Unmanaged Groundwater	O (E)	9 (6.8)	4 (5.5)	5 (6.0)	8 (4.3)	8 (7.7)	3 (6.8)	**11.710**	**0.039**
Climate Change	O (E)	5 (7.0)	1 (5.7)	10 (6.1)	6 (4.4)	12 (7.9)	4 (7.0)	**19.450**	**0.002**
Endangered Species Act-related Problems	O (E)	5 (6.6)	7 (5.7)	3 (5.8)	3 (4.1)	11 (7.5)	7 (6.6)	7.270	0.202
Insuffcient Water Use Efficiency	O (E)	7 (6.3)	6 (5.1)	5 (5.5)	4 (3.9)	6 (7.0)	6 (6.3)	0.760	0.980
Regulatory Problems	O (E)	2 (6.1)	5 (4.9)	3 (5.3)	4 (3.8)	11 (6.8)	8 (6.1)	**11.130**	**0.049**
Water Rights Systems	O (E)	5 (5.5)	4 (4.5)	2 (4.8)	4 (3.4)	9 (6.2)	6 (5.5)	3.140	0.678
Water Quality	O (E)	9 (5.3)	1 (4.3)	4 (4.7)	2 (3.3)	5 (6.0)	8 (5.3)	*10.82*	*0.055*
Detiorating Awuatic Ecosystems	O (E)	7 (4.2)	2 (3.44)	3 (3.7)	2 (2.6)	9 (4.8)	0 (4.2)	***14.57***	***0.012***
Sporadic Funding Sources	O (E)	5 (4.1)	2 (3.3)	7 (3.5)	3 (2.5)	2 (4.6)	3 (4.1)	*7.90*	*0.162*
Flood Risk	O (E)	4 (4.1)	2 (3.3)	10 (3.5)	2 (2.5)	2 (4.6)	1 (4.1)	***20.38***	***0.001***
Water Transfer Problems	O (E)	3 (4.1)	6 (3.3)	1 (3.5)	1 (2.5)	5 (4.6)	6 (4.1)	*8.36*	*0.138*
Undervaluing Water	O (E)	7 (3.5)	0 (2.8)	2 (3.1)	2 (2.2)	5 (3.9)	3 (3.3)	*9.08*	*0.106*

a In addition, the 'Other' category was omitted from statistical analysis because the mixed nature of this group makes interpretation of group differences difficult, and there were so few people that at least 20% of cells had expected values of <5, making Chi-squared values suspect.

Table 5 Overcoming obstacles to water problems (% of respondents)

Solution	Academics (16)	Agricultural Agency (13)	Operations / Flood (14)	Politicians / Staff (10)	Regulatory / Environmental (18)	Urban Agency (16)	Other (7)	Total (94)
Educate Public and Politicians	**44**	31	**79**	60	33	38	43	46
Strengthen Leadership and Improve Decisionmaking	19	**54**	43	30	**72**	44	**57**	46
Reduce Polarization and Political Dysfunction	25	38	50	**70**	56	**50**	14	45
Level the Playing Field (no special interests)	6	38	36	20	61	25	43	33
Develop Sustainable Funding	25	23	36	40	28	44	43	33
Develop a Holistic/Long-term Vision of Water	31	—	57	30	28	**50**	14	32
Improve Relevance and Quantity of Scientific Information	19	31	21	20	6	31	14	20
Reform Institutions	19	15	21	10	22	13	14	17
Manage the Delta	13	31	7	10	22	6	14	15
Base Water Policy on Science	31	8	14	10	11	13	—	14
Capitalize on Crises	—	8	14	20	17	13	29	13
Improve Data (Monitoring and Accessibility)	13	15	14	10	6	13	29	13

NOTE: For each respondent, the Table includes up to 10 answers (up to five answers each for questions 4 and 5, see Table 1). Answers to both questions are expressed in terms of potential solutions. Responses noted in group interviews were counted twice. Bold values indicate the highest percentage for each subcategory of respondents.

Table 6 Number of observed (O) and expected (E) respondents that discuss solutions in each water sector category. Bold values indicate statistically significant differences between water sectors (n = 87, df = 5); test may be invalid for responses highlighted with italics due to small cell sizes[a].

Problem		Academics (16)	Agricultural Agency (13)	Operations / Flood (14)	Politicians / Staff (10)	Regulatory / Environmental (18)	Urban Agency (16)	Chi-square	*p*-value
Educate public and politicians	O (E)	7 (7.4)	4 (6.0)	11 (6.4)	6 (4.6)	6 (8.3)	6 (7.4)	9.64	0.086
Strengthen leadership and improve decisionmaking	O (E)	3 (7.2)	7 (5.8)	6 (6.3)	3 (4.5)	13 (8.1)	7 (7.2)	**11.21**	**0.047**
Reduce polarization and political dysfunction	O (E)	4 (7.5)	5 (6.1)	7 (6.6)	7 (4.7)	10 (8.48)	8 (7.5)	6.25	0.283
Level the playing field (no special interests)	O (E)	1 (5.15)	5 (4.2)	5 (4.5)	2 (3.2)	11 (5.8)	4 (5.15)	***13.21***	***0.022***
Develop sustainable funding	O (E)	4 (5.2)	3 (4.2)	5 (4.5)	4 (3.2)	5 (5.8)	7 (5.2)	2.37	0.796
Develop a holistic/long-term vision of water management	O (E)	5 (5.3)	0 (4.3)	8 (4.7)	3 (3.3)	5 (6.0)	8 (5.3)	***12.40***	***0.030***
Improve relevance and quantity of scientific information	O(E)	3 (3.3)	4 (2.7)	3 (2.9)	2 (2.1)	1 (3.7)	5 (3.3)	4.45	0.487
Reform Institutions	O (E)	3 (2.8)	2 (2.2)	2 (2.4)	1 (1.7)	4 (3.1)	2 (2.8)	1.16	0.949
Manage the Delta	O (E)	2 (2.4)	4 (1.9)	1 (2.1)	1 (1.5)	4 (2.7)	1 (2.4)	5.20	0.392
Base water policy on science	O (E)	5 (2.4)	1 (1.9)	2 (2.1)	1 (1.5)	2 (2.7)	2 (2.4)	4.37	0.498
Capitalize on crises	O (E)	0 (1.8)	1 (1.5)	2 (1.6)	2 (1.2)	3 (2.1)	2 (18)	3.57	0.613
Improve data (monitoring and accessibility)	O (E)	2 (1.8)	2 (1.5)	2 (1.6)	1 (1.2)	1 (2.1)	2 (1.8)	0.98	0.964

a In addition, the 'Other' category was omitted from statistical analysis because the mixed nature of this group makes interpretation of group differences difficult, and there were so few people that at least 20% of cells had expected values of <5, making Chi-squared values suspect.

a percentage of respondents discussed an issue, it means that a percentage of respondents voluntarily raised the issue and the interviewers did not lead respondents to the subject. The findings presented below are based on what was heard during interviews. Where relevant, we provide citations that illustrate the extent to which respondent views correspond with the scientific and policy literature, but we do not aim to systematically measure the extent to which opinions and beliefs expressed conflict with the facts.

We start by discussing problems and policy actions mentioned most often, drawing on responses to the first three interview questions. We then discuss obstacles to improving water policy and potential solutions, which correspond to the last two questions. Given the considerable overlap in responses to these two groups of questions, we pooled the answers into summary tables. We conclude with an overview of major findings and then provide some policy recommendations based on these results. To provide a flavor of the discussions, we provide anonymous quotations throughout the paper.

LONG-TERM WATER PROBLEMS AND POLICY ACTIONS

The first three questions asked respondents to identify the most important long-term water policy issues for the state and to list the most useful state and federal policy actions for long-term water management. Results of the most commonly discussed problems are summarized in Tables 3 and 5. In the subsections below we briefly discuss each major problem. We group similar problems together into five broad categories for ease of discussion: the Delta, water governance and institutions, water supply and flood management, environmental protection, and water laws and economics.

The Sacramento–San Joaquin Delta

> "Absent stronger leadership, things will not get better."

Unsustainable management of the Delta—part of the West Coast's largest estuary and a major conveyance hub within California's water supply network—was the most commonly discussed water problem, with 57% of all respondents listing it among California's top five water problems (Table 3). Interview findings reinforce Delta problems discussed in the literature for several decades (Hart 1982; Hundley 1992, 2001; Carle 2000; Hanemann and Dyckman 2009) and suggest that little progress has been made in resolving them. Politicians as a group were particularly sensitive to this topic (90% listed it as a top problem), although chi-squared testing indicated the likelihood of considering the Delta a major problem did not dependent on water sector category (Table 4).

Water supply reliability, ecosystem function, the condition of Delta levees, water quality, and governance structure were commonly cited Delta problems. Approximately one-fifth of all respondents considered improving water supply conveyance through or around the Delta a top policy action for long-term water management. But reasons varied, with some respondents supporting better conveyance primarily to support Delta ecosystems, others to improve water supply reliability, and still others to improve drinking water quality. Similarly, opinions were split on the best system of governance for the Delta. Roughly equal numbers of respondents favored the continued development of the Bay Delta Conservation Plan (BDCP)—a habitat conservation plan that would support Delta ecosystems while improving water supply reliability for water users—as thought that an entirely new approach was needed. For this latter group, concerns were raised that the BDCP would have the same (unsuccessful) outcome as CALFED, an earlier policy process.[4]

Most respondents thought the state government should be at the helm in addressing the Delta's woes. More effective leadership from the governor's office, the California legislature, and state agencies came up repeatedly when respondents were asked about possible solutions. Indeed, many felt that the current lack of strong leadership contributes to the ongoing problems in the Delta. The following sentiments represent this view:

- "I blame [the problems in the Delta on] the lack of strong leadership by our elected officials as well as within our state agencies."
- "[We need to] merge science on the Delta with political leadership to bring about change that may be unpopular with a significant fraction of the stakeholders."
- "We're missing leadership—a governor that leads. We've been hypnotized by the public participation process, and the belief that the way to make decisions is by consensus. We need real leadership where leaders figure out the issue, find the supporters and the fatal opponents, make sure all interests are and feel heard, but are willing to make decisions that not everyone will agree with."

These comments underscore beliefs that better leadership is a precursor to fixing the Delta, as well as current disfavor among some observers with the consensus approach to solving Delta problems that was the hallmark of the CALFED era and that some stakeholders continue to favor. These opinions mirror the argument by Hanemann and Dyckman (2009) that the consensus approach was the result of the state of California's passing off leadership duties to involved parties rather than providing leadership and decisionmaking.

Despite general consensus that the Delta poses a major problem for California water management, there was less agreement about what should be done to fix it, or even what is currently going wrong. Some proposed solutions were vague, such as "the Delta should be fixed." Current policy attention on the Delta also generated some resentment, prompting one respondent to remark: "Contrary to popular belief, there are parts of the state that are not tied to the Delta," and another to say: "Water policy is too Delta-centric right now."

4 In all, only 10% of all respondents specifically addressed the issue of Delta governance. CALFED was a state-federal program to address Delta problems that operated from the time of the Bay–Delta Accord (signed in 1994) through 2006, when the California legislature cut funding for programs.

Dysfunctional Institutions and Water Governance

Fifty-six percent of respondents expressed frustration with dysfunctional institutions, a perceived lack of coordination, and lack of leadership (Table 3). They wanted elected officials to hold public service duties in higher regard than their desire for re-election, and to have the courage and tenacity to make difficult decisions even if not everyone agrees with the outcome. This was the most frequently-raised problem for both urban and agricultural water agencies, as well as for state and federal water supply and flood control employees (Table 3). There were statistically significant differences across water sectors regarding this issue (Table 4). Interestingly, response patterns differed across groups who might be thought of as "institutional insiders"—whereas the project operations/flood control group was among the most likely to note these types of concerns, those affiliated with regulatory agencies and environmental organizations—many of whom are also "insiders"—were among the least likely to consider institutional dysfunction to be a problem.

State Governance

> "It's like herding cats to get agencies to work together."

Nearly half of all respondents (49%) felt that the state agencies that manage and regulate water in California were ineffective, with inadequate resources to accomplish their missions, lack of independence from the Governor's office, and poorly defined or overlapping authorities. Such sentiments are echoed in the scientific literature (Livingston 1995), although academic papers generally do not describe problems of specific agencies or institutions. Respondents singled out the ineffectiveness of the Department of Water Resources (DWR), State Water Resources Control Board (SWRCB),[5] and Department of Fish and Game (DFG)[6] as major barriers to effective water management in California. These agencies were alternately described as inactive in their duties, redundant, inconsistent, archaic, subject to political whim, weak, lacking political cover, lacking clarity of goals, or otherwise dysfunctional. These views are a unique outcome of expert-opinion surveys and are not reflected in public survey data, because they generally express insider views and the arcane nature of water management.

Regarding solutions, 46% of respondents highlighted the need to foster strong leadership and 45% wanted to reduce political polarization/dysfunction to improve water policy and management in California (Table 5). Citing the need to strengthen leadership was again related to water sector affiliation, with lower-than-expected mention by academics and higher-than-expected mention by employees of regulatory agencies and environmental organizations (Table 6). Respondents wanted to see leaders work better with each other (for example cooperation between the governor's office, legislature, and state and federal agencies). However, the most common sentiment expressed was that the state needs leaders who make decisions rather than "cling politically to the status quo." Respondents believed that this would require political will, some degree of risk-taking, and a declaration that issues would be dealt with whether groups participated or not. (There was a good deal of resentment toward uncooperative groups or interests being able to derail actions and decisions on issues, essentially creating essentially a system that rewards bad behavior.) At the agency level, respondents believed that leaders must be given political independence, clear goals, an adequate budget, and the drive and commitment to solve problems. One respondent summarized many frustrations with agency leadership well: "Reorganizing agencies doesn't target the root of the problems. They need a commitment to attacking problems and being aggressive."

Water Project Operations

> "It is not sensible to expect DWR, which is supposed to be a steward of the resource, but is also a purveyor of water (with contracts), to function in an even-handed manner."

5 The SWRCB is responsible for the administration of water rights and state and federal clean water legislation.

6 DFG is responsible for the administration of the state's Endangered Species Act and other state ecosystem protection laws under the Fish and Game Code.

Criticisms of state agencies reflect, in part, DWR's organizational shortcomings, an organization that currently has responsibility for general water resource planning and management, as well as operational responsibility for the State Water Project (SWP), a major component of the state's water system (DWR 1957). Roughly one-sixth of all respondents considered separating the SWP from DWR to be a high priority, with the SWP operated as a public utility or by a new state agency because DWR cannot effectively manage water for the public good while simultaneously acting as a water utility. The efficiency theme was also raised in conjunction with the separate operation of the (SWP) and the federally-owned Central Valley Project (CVP). Nearly one-fifth of all respondents mentioned the idea of merging the two projects as a priority (dominant recommendations were for joint operation by a new public utility). In this view, operating the projects jointly could facilitate water transfers and more efficient water operations, since both projects draw water from pumps in the southern Delta, operate complementary storage and conveyance infrastructure, and serve large regions south and west of the Delta. A few respondents supported the idea of a merger but did not want California to inherit the existing federal liability for salinity and drainage problems associated with the CVP in the western San Joaquin Valley.

Aging infrastructure was another problem routinely discussed in conjunction with the SWP and CVP. In the words of one respondent: "We've been living off of the investments in infrastructure made by our grandparents." There was concern that California lacks the funding or the will to address the maintenance backlog on the water projects.

Sporadic Funding

> "We've become addicted to voter-approved bonds every few years. The voters have been very kind, and the water managers start to see that as a bit of an entitlement. But it's unsustainable and a poor way to do water planning. It works for short-term projects but not for implementing long-term projects."

An overarching shortcoming noted at the state level was a lack of reliable funding. Nearly one-third of all respondents raised the funding issue, highlighting difficulties associated with the sporadic nature of bond funds to support various management functions (Table 3). Some respondents specifically observed that "we don't fund environmental management very well in this state." In this view, funding environmental protection and enhancement has become an ongoing need, requiring the development of stable, long-term funding sources. Among alternatives to bond funding, some recommended a "beneficiary pays" or user fee approach for water use, in which ratepayers cover the full costs of water projects that benefit them, including the environmental costs. Others supported the introduction of statewide water fees or taxes. Several recommended the introduction of regional stewardship fees for enhancing the environment, drawing on the model of the per acre-foot fee charged by the Metropolitan Water District (MWD) of Southern California on all wholesale water sales.[7] Cost-based water pricing—the user fee approach—was particularly emphasized by academics and respondents from regulatory or environmental groups (and less emphasized by representatives from local agricultural and urban water agencies).

Federal Governance

> "Money. Just send money."

Consistent with concerns that California does not have adequate state-level water planning, respondents also expressed the need for a clear national water policy with consistent direction and support that does not change with administration. About 15% felt that there currently is too little federal engagement with water problems in California and other western states. The same types of redundancies, inconsistencies, and inflexibility that plague state agencies were also described for federal agencies. The proposal to transfer the CVP to state control, noted above, reflected a general feeling that the federal government should provide California with financial

7 Metropolitan's per acre-foot stewardship fees, in place since the early 1990s, are used to support water conservation efforts and the development of local supply sources.

support for water policy, management, and stewardship but allow the state to manage and regulate its own resources. Although some respondents thought federal agencies did their regulatory jobs well, a greater number wanted to see California given more authority to enforce regulations on its own, with the federal government simply providing oversight (as occurs now with the Clean Water Act). In large part, this proposal reflected a desire to streamline administrative burdens associated with having to get numerous state and federal authorizations to implement or alter various projects.

Water Supply and Flood Management

Unsustainable Water Supply

> "We're in a man-made, permanent drought."

Nearly half of all respondents (48%) cited unsustainable water supplies as a major issue the state faces (Table 3). Although this is a substantial proportion, the experts we interviewed showed less concern than that expressed by the general public in two opinion surveys conducted around the same time, in which 69% to 81% of Californians thought the state's water shortage was at least somewhat of a problem (Baldassare and others 2010; Metz and Byerly 2010).[8] In light of the many problems facing the Delta and a perception that diversion rights on most large river systems are already over-allocated, some respondents put little emphasis on expanding large water projects (politicians were a notable exception). Instead, they suggested regionally-appropriate solutions involving local water supplies, recycling and reuse programs, desalination, stormwater capture, reservoir re-operation, and the joint management of surface and groundwater through conjunctive use strategies. These strategies have been described in the literature (for example Vaux 1986; Pulido–Velazquez and others 2004; Harou and others 2010). However, respondents also noted obstacles to more widespread use of the above solutions, including funding, social acceptance, and government policies that inhibit implementation, which receive less attention in the literature. The challenges to implementing local and regional water supplies—as well as how these challenges might be overcome—highlight the advantages of seeking the opinions of water managers and other experts. Identifying obstacles to improving water supply reliability with local water supplies—and overcoming those obstacles—are areas of water resource management that merit more research.

Unmanaged Groundwater

> "Groundwater is a glaring hole in our water resources management."

Lack of groundwater management was the fourth most important issue noted by all respondents (Table 3), and chi-squared tests indicate that opinions vary across water sectors, with higher-than-expected levels of concern among academics and politicians and lower concern among representatives of urban and agricultural agencies (Table 4). The low priority placed on groundwater among urban agencies (cited by only 3 of the 16 respondents in that group) reflects that many of those respondents were from Southern California, where most groundwater basins are relatively well managed through adjudications or special groundwater management districts (Blomquist 1992). Politicians were most likely to list unmanaged groundwater as a top water problem—80% listed it as a problem—perhaps reflecting the difficulties of passing statewide legislation to better manage this resource, given local resistance to state intervention.[9]

Opinion varied regarding solutions. Most respondents believed the state should play a leadership role in encouraging groundwater management, but a handful of respondents believed the state should desist, with one stating: "Don't have the state regulate groundwater until they prove they can manage surface water. They're already like a rabid monkey with a hand grenade with surface water—we'd be mad to give them another one." Among those favoring state involvement, some argued that basin monitoring with man-

8 Because these survey questions were not open-ended, the results are not strictly comparable to our open-ended expert interviews, where the problem was mentioned only if experts chose to raise it.

9 For instance, efforts to require groundwater measurement and reporting have failed numerous times over the past decade. In a comprehensive legislative package on water negotiated in late 2009, not long before our interviews, the bill addressing groundwater measurement (SBX7 6) was passed, but only after being watered down so that local authorities are only required to report basin levels, not withdrawals.

datory reporting was adequate, while others sought adjudications, following the Southern California model. A few respondents recommended using the fear of regulation as a threat to force groundwater monitoring and reporting, although one respondent felt it was in the interest of groundwater users to wait until problems became catastrophic so that costs of management costs would fall on taxpayers rather than local users. Most also believed that water supply reliability would be more enhanced—and money better spent—by managing groundwater conjunctively with surface water than by building new surface storage reservoirs. The Kern Water Bank was cited as a successful model of conjunctive use (for a description of this bank, see Thomas 2001).

Climate Change and Flood Risk

> "The technologies of the 1940s are probably not the answer."

Climate change and flood management were major areas of concern for 41% and 27% of all respondents, respectively (Table 3). Statistically significant relationships exist between opinion and water sector affiliation (Table 4). More than two-thirds of the operations/flood and the regulatory/environmental groups perceived climate change as a top water problem, while urban and agricultural agency respondents rarely mentioned it (Table 3). Similarly, over 70% of respondents in the operations/flood category ranked flood risk as a top problem. The low ranking of flood management among urban and agricultural agencies (6% and 15%, respectively) reflects that few of these agencies have flood management responsibilities (Table 3). In contrast, the lower-than-expected levels of water agency concern with climate change may be of some concern, given model predictions of reduced seasonal water storage in the mountain snowpack and potentially also reduced average precipitation (Hanak and Lund 2012; Null and others 2010).

Nearly 10% of all respondents believe that policy and funding to adapt to climate change should be set at the national level, including federal leadership for reducing CO_2 emissions. Major concerns about climate change included reduced snowpack, extended drought, and increased flood risk. Among those who expressed these concerns, there was general consensus that available water supplies would decrease in the future, which, combined with population growth, implies that the state needs to be prepared for major, long-term water shortages. Adaptation strategies coincide with those discussed in the water supply section above. A few respondents felt there is so much uncertainty regarding climate change that money should not be spent on the problem until understanding is improved.

While the scientific literature has many studies that estimate climate-driven changes to California's hydrologic regime (Dettinger 2005; Knowles and Cayan 2002; Null and others 2010), there are noticeably fewer papers detailing specific ways to incorporate climate-driven hydrological changes into water operations, policy, and regulatory processes. [Novel examples include Willis and others (2011), who examined how to adapt Sacramento Valley reservoir rule curves to a warmer climate, and Viers (2011), who recommended incorporating climate change in the FERC re-licensing process.] This is a sizeable information gap in the literature. Our survey suggests that water managers and other experts would benefit from studies that better describing concrete ways to adapt management and policy in light of changing climatic conditions.

To incorporate climate change effects on flood control, respondents suggested several actions: revising the rule curves for flood storage space in existing reservoirs to accommodate more rainfall in the winter and early spring (a result of reduced snowpack),[10] improving infiltration (reducing runoff) in upland or mountain regions through better land management, and stopping new development in floodplains. One respondent offered an innovative suggestion:

> "Forty or fifty years ago we used to think in terms of big costly dam projects. Now, all the good sites are gone and we don't have the resources or will to build. We should consider building 'micro-storage—for example, 3,000 small projects of little catchment basins,

10 Reservoirs that provide storage for both flood waters and water supply have rule curves that determine the schedule of space kept available for flood waters. A changing schedule of runoff as a result of climate warming implies the need to change these rule curves, to make more space available for flood storage.

> holding ponds, things designed to encourage less runoff and more percolation. This could substitute for snowpack in a sustainable, long-term way."

Others mentioned the potential need for levees around airports and water treatment plants to protect existing investments from future flooding. Flood-risk concerns also included the difficulties of financing flood protection, aging levees, and the state's exposure to costly liability for levee failures in the wake of the 2003 Paterno decision.[11]

Environmental Protection

Endangered Species Act-related Problems

> "We may have to let one species go to preserve the whole ecosystem, which is the opposite of the ESA."

Concerns with the Endangered Species Act (ESA), the federal law charged with protecting species from extinction, were described by nearly 40% of respondents (Table 3), and the prevalence of such concerns was not correlated with water sector (Table 4). Although there was a general feeling among respondents that the ESA is not working particularly well, perceptions varied about what was wrong with the law or its implementation. Whereas some viewed ESA-related water management as wasteful or outside California's reasonable and beneficial use requirements, others took the opposite view, calling for more robust and timely enforcement of the law, so that people cannot "dither in the hopes that species die."

Regardless of these divergences, nearly all respondents who discussed the ESA believe that its focus should be on ecosystem health and function instead of single species. They felt the law should have a broader definition of what constitutes success and failure, such as ecosystem function, ecosystem services, or self-sustaining aquatic communities. This view is represented in the scientific literature (e.g., Pikitch and others 2004), and it is also reflected to some extent in legal and regulatory reforms since the 1990s that aim to encourage the implementation of multi-species habitat conservation plans under both federal and state law.[12] Although most existing habitat conservation plans in California have focused on terrestrial habitat (Hanak and others 2011), the Bay–Delta Conservation Plan (BDCP), in development since 2006, seeks to develop such a plan to address aquatic and terrestrial species declines in the Delta (BDCP 2010). While generally supportive of the concept of ecosystem-based approaches, the scientific literature also highlighted the difficulties inherent in implementing them effectively for the benefit of species (e.g., Clark and Harvey 2002; Clark and others 2002, Rahn and others 2006). Researchers have also pointed out rigidities in the ESA in the face of external factors such as climate change, which may force tradeoffs among species, something the law did not anticipate when it was established in the early 1970s (Hanak and others 2011). Although some respondents flagged this problem, they offered little discussion regarding how stationary regulatory processes (such as the ESA) might be enforced or adapted to a non-stationary climate.

Other Regulatory Problems

> "We have an archaic and dysfunctional regulatory system."

Nearly two-fifths of all respondents mentioned other types of regulatory issues as a major long-term problem for California water (Table 3), and these views were more prevalent both among those affiliated with regulatory and environmental organizations as well as among local water agencies, which are frequently the regulated parties (Table 4). Problems that were mentioned included Biological Opinions[13] for listed

11 In the Paterno decision, the California Supreme Court determined that the state was responsible for damage from the failure of federally-authorized levees even if they were constructed and are maintained by local authorities. See DWR (2005).

12 Habitat Conservation Plans (HCPs) were added as a potential compliance mechanism for the federal ESA in 1982, and multi-species HCPs have been actively encouraged since the 1990s (Frampton 1996). Natural Community Conservation Plans (NCCPs) are the equivalent under state law, and were introduced in 2003. These instruments encourage regulated parties (typically those altering land or water resources in ways that could detrimentally affect species listed as threatened or endangered) to develop comprehensive ecosystem-based approaches to address species declines.

13 Biological Opinions are documents prepared by the federal agencies responsible for ESA administration (U.S. Fish and Wildlife Service and National Marine Fisheries Service, now NOAA Fisheries) for projects that are subject to the ESA because they may cause harm to listed species.

species that rarely present a coherent set of goals for water users or do not use recent science, regulatory redundancy (one respondent listed seven different offices which regulated fish screens), or compartmentalized regulatory processes in which different offices do not interact with each other. Both regulators and regulated parties offered suggestions for making the regulatory process more efficient and effective. Regulatory 'carrots and sticks' to encourage some behaviors and limit others is one respondent recommendation to streamline water management. Less paperwork for a quick, efficient regulatory process would serve as a strong incentive for matters ranging from water transfers to groundwater recharge to recycled water use.

Water Quality

> "What quality of water is healthy water?"

Protecting water quality in both surface and groundwater was especially important to academics and urban agency representatives (Table 3 and 4). Although problems with environmental water quality were typically considered to be an emerging issue rather than a major current challenge, some respondents noted the thousands of miles of impaired waterways as evidence that California is already failing to adequately protect water quality.[14] Respondents generally wanted those entities that discharge pollutants to be held responsible for water-quality impairment. Some ideas to improve water quality throughout California included raising regulatory standards, completing the ongoing effort to establish total maximum daily loads (TMDLs) to regulate contaminants for all basins, improving management of wastewater and non-point pollution (e.g., stormwater and irrigation runoff) discharged to rivers, and tightening regulation and monitoring of groundwater quality.

Although salts, nutrients, and water temperature were the most commonly discussed impairments, respondents also worried about pharmaceuticals and untested chemicals in surface and groundwater, particularly for drinking water systems. Suggestions to address these contaminants included adopting a 'zero tolerance' objective for hormones or other pharmaceuticals; requiring product labeling for contaminants that have not been fully tested; implementing the state's new Green Chemistry Initiative, which aims to improve the understanding of chemicals put into production, or disclosing information on chemicals found in various products.[15] However, some respondents (particularly in urban agencies) believed drinking water standards were too stringent, noting that with improving detection technologies there is a tendency to assume something is harmful just because it is possible to detect. In this sense, technology is outstripping understanding. These respondents believed that acceptable contaminant levels should be based on the risk to human and ecological health, which would reduce water treatment costs while ensuring reasonable levels of protection.

Deteriorating Aquatic Ecosystems and Instream Flows

> "Accept that we live in a managed ecosystem and that we need to identify which values we want to manage."

Consistent with the concerns over the ESA, nearly 30% of respondents listed deteriorating aquatic ecosystems as a water problem in California (Table 3). The mention of this problem appears to vary significantly with water sector. It was raised by 44% of academics and 50% of regulatory/environmental respondents, but by no respondents from urban water agencies and by only two from agricultural agencies (Table 4). Few concrete suggestions were given regarding solutions. Approximately one-tenth of all respondents—particularly from the regulatory/environmental and academic groups—called for the development of instream flow standards for all major rivers in California to protect the public trust. Such standards were typically suggested as a way to incorporate more holistic management of aquatic ecosystems (rather than the species-

14 Water bodies can be classified as impaired under provisions of the federal Clean Water Act. In 2004, 93% of California's river miles, 93% of California's lake acreage, and 98% of its estuarine square miles were listed as impaired (USEPA, undated).

15 For more on this initiative, see *http://www.dtsc.ca.gov/pollutionprevention/greenchemistryinitiative/index.cfm*.

by-species approach of the ESA).[16] Another common sentiment—more likely to be mentioned by regulated parties—was the desire for environmental and regulatory consistency, where requirements are clear and do not change, so that after instream flows have been met water users are free to use their water without fear of additional requirements, commitments, or regulations.

Water Laws and Economics

Water Rights and Water Transfers

> "We need the ability to transfer water east to west."

Water rights and water transfers are two related issues, since transfers allow market-based reallocation of water rights on a temporary or permanent basis. One-quarter of all respondents highlighted obstacles to water transfers as a major problem for California water management, and an even higher share (34%) felt that California's water rights system was a major issue (Table 3). Although regulatory and environmental sector representatives appeared more likely than others to raise problems with transfers, these differences are not statistically significant (Table 4). Members of different groups appeared equally likely to mention problems with water rights (Table 4).

Those concerned with water rights were roughly evenly divided as to whether the solution lay in water rights reform (19%) or better enforcement of existing rights (16%).[17] The water rights reform camp characterized the current system as archaic and unfair, and called for reform to reallocate supplies. The topic brought out strong feelings, with resentment that historical water rights priorities have resulted in water "winners and losers" (compounded by water subsidies), with little emphasis on efficient use. As one respondent summed up the problem: "You've got this theoretical construct with seniority rights... but the reality is that when conflicts occur, there is usually some sort of deal made that doesn't follow the water rights system."

Respondents who emphasized the importance of better water-rights enforcement tended to focus on the potential of water transfers to re-allocate water—with enforcement of rights being seen as a key to facilitating water marketing. Those working for urban and agricultural water districts noted a particular need for increased east-to-west transfers south of the Delta (given reduced potential for north-to-south transfers with new restrictions on Delta pumping). They also reiterated findings from the literature that numerous factors hamper water transfers, including institutions, infrastructure, politics, regulatory processes, endangered species, and water prices (Gray 1996). Although these respondents generally considered it unnecessary to reform the water-rights system, some noted that adjustments may be needed to address the over-allocation of CVP contracts (relative to delivery potential) as well as anticipated water-supply reductions from climate change. Some respondents also mentioned the need for policies to protect communities in source regions (such as Northern California), so they are not "sucked dry" by water transfers. These concerns reflect the incomplete protections currently provided by California water law for groundwater users who might be adversely affected by the market, and by the lack of formal protections for communities from other economic effects (Hanak and Dyckman 2003).

Under-valuing Water and Water Use Efficiency

> "The fact that we have agricultural users getting water at subsidized rates and turning it around and selling it at a profit is indicative of an incredibly broken system."

Roughly one-fifth of respondents considered artificially-low water prices a major factor underlying current water problems in California (Table 3). They stressed the role that price signals play in encouraging more efficient water use. However, a sectoral divide was apparent on this issue: those concerned with pricing questioned whether water was being used wisely in the agricultural sector, particularly in light of subsidized water prices for recipients of CVP

16 Some respondents felt that although the state has public trust responsibilities (Sax 1980; Wilkinson 1989), there is no clear process as to how to implement them.

17 See Hanak and others (2011) for a description of the origins of different types of California water rights.

water, while representatives from agricultural water districts did not raise the issue of undervaluation of water as a problem (Table 4).[18] Respondents who thought low-valued crops were using an unjustified portion of the state's water resources encouraged full-cost water pricing (for both urban and agricultural users) to cue conservation, reduced reliance on unstable bond funding, and promoting a shift toward higher-value, lower-water-using crops. A handful of respondents also noted the importance of improving environmental water use efficiency to ensure that water allocated to the environment is improving instream conditions.

Opinions differed on the best types of rate structures, with some favoring volumetric pricing applied equally to all water users within a district and other favoring a tiered pricing system with variable base allocations, such as that used by the Irvine Ranch Water District (IRWD) in Southern California. Under such systems, water users are given a larger allocation at the lowest tier if they have larger households and larger lots, so all water users face similar incentives to improve water-use efficiency (Hall 2009). Some respondents feared that many urban water agencies could not cover their fixed costs with water conservation programs (since fixed costs need to be covered even if water use declines). They noted that an advantage of allocation-based systems such as IRWD's lies in its ability to cover fixed costs while promoting conservation.[19]

OVERCOMING OBSTACLES

> "Most of the biggest obstacles are long-standing and entrenched. As a result we tend to address problems by tinkering around the edges. I am not convinced that more tinkering will get us very far."

The last two survey questions asked respondents to identify the most significant challenges to effective water policy and to provide ideas on how to overcome them (Table 1). Overlap in the themes covered led us to combine responses to these questions (Table 5). Some proposed solutions related directly to specific policy problems (e.g., steps to strengthen water conservation, manage the Delta, and develop sustainable water supply sources...) and have been discussed above. Here, we focus on the more general, cross-cutting themes including public education, special interests, holistic water management, and the role of science. Opinions did not vary significantly across groups on the importance of these topics—except for leveling the playing field to reduce the effect of special interests, and developing a holistic or long-term vision for California's water management (Table 6).

Although Table 5 illustrates broad agreement for a handful of solutions, measuring the extent of agreement about how they should be achieved is largely beyond the scope of this study. Respondents generally offered very broad perspectives, possibly reflecting the question posed, which was to ways to overcome current water problems (rather than how to implement specific solutions). But even though most suggestions lacked detail (e.g., how to garner support for ideas, what separates a 'special interest' from any view that differs from ones own...), these opinions are valuable because they offer a uniquely practitioner perspective that rarely reaches the scientific literature.

Education

> "Water is a hugely arcane and complicated subject, in which ignorance is the dominant state."

Educating the public and policy makers was the most commonly offered recommendation for overcoming challenges facing water policy, mentioned by nearly half of all respondents (Table 5). This idea is reinforced by Kahrl (1978) who describes water policy and management as multidisciplinary and "immensely complex." Respondents felt that most Californians were poorly informed about where their water comes from—and its value, where wastewater goes, the importance of sustainable funding for water management and regulation, and declining water quality.

18 Hanak and others (2010) point out that the commonly held view that these subsidies are "unfair" may be overstated, because today's farmers have paid for the subsidies in higher land prices.

19 The goal of such systems is to cover fixed costs with revenue from the lower tiers and to use revenue from the upper tier(s) to fund conservation programs and related actions, such as stormwater management.

These beliefs matched public opinion survey data that indicates that misconceptions about water are common. [For instance, 71% of Californians believe more water is used for indoor uses than outdoor uses, whereas outdoor use is higher in most parts of California (Metz and Byerly 2010)]. Respondents thought that better educating the public about water problems could drive more informed policymaking.[20] Specific ideas for how to improve public water education were varied, ranging from emphasizing critical thinking in grade school, to holding county-level workshops, or developing coherent messages for water education (instead of the agendas of particular agencies or organizations).

There was general agreement that acquiring expertise in water policy and management takes time and effort, and that legislative term limits were another impediment to politicians acquiring the needed expertise. One practitioner said: "We need legislators that are around long enough to develop self- and staff-expertise in their areas of interest, like water and other resources. Now, the knowledge and expertise at the legislative level is mostly fostered by moneyed interests and lobbyists."

Special Interests

> "Without a level playing field, reform will be unlikely."

Given California's culture of conflict regarding water issues, 33% of all respondents felt that stakeholders come to the table with deeply entrenched and unyielding perspectives. Holding this view relates to water-sector affiliation, with 61% of the regulatory/environmental sector—but only 6% of academics—discussing special interests (Tables 5 and 6). While any group that takes action on behalf of voters could be defined as a 'special interest' (Grossman and Helpman 2001), it was lack of cooperation and the ability to stall action with dissent that cut to the heart of respondents' concerns. Respondents believed that change would be difficult to achieve as long as the power and financial backing of interests remain uneven (and sometimes grandfathered under the legal and regulatory structure). The following statements illustrate this view:

- "There is a mismatch between the folks who benefit from the current system and their political power, and the folks who have a more realistic and appropriate vision of where we should be going."
- "[We need to] level the playing field among the vested/moneyed interests, and the array of environmental quality interests whose products are essentially impossible to properly monetize."
- "There is a large government and consultant bureaucracy dedicated to the current system."

Specific solutions for "leveling the playing field" among stakeholders included reforming water rights, eliminating term limits, and incentivizing cooperation among stakeholders.

Holistic Planning and Policy

> "Flood guys have to talk to watershed guys, who have to talk to water supply guys."

Many deplored the current compartmentalized approach to governance structure and funding, with nearly one-third calling for more holistic management approaches (Table 5). Again opinion was significantly associated with water sector, with at least half of respondents from the operations/flood and urban agencies seeing this as an obstacle to overcome, while no agricultural agency respondents discussed it (Table 6). Suggestions were somewhat vague, but respondents cautioned that California must strengthen coordination among various water management activities such as water supply and flood control, human water uses and ecosystem function, and surface and groundwater. Likewise, many felt that "some 'water policy' problems— like land and energy use, and food and biofuel production—are really larger policy problems." Integrated Regional Watershed Management Planning was one approach recommended for managing watersheds holistically. The emphasis was not only on planning, but also on

20 Given the diversity of views on the nature of solutions, it is quite possible that respondents from different sectors would perceive such education efforts to be more or less successful depending on the content and the messages conveyed.

action: "[California needs to] transform words about integrated resource management into real actions, and move watershed planning from talk to reality." Although California has made some progress since the early 2000s in linking water and land-use planning through legislation, respondents urged stronger laws, so that new development must identify firm water supplies before construction and be prohibited from locating in floodplains.[21]

Better Data and Science

"Science tells you what your options are."

The need for better baseline data was considered a major long-term problem by 20% of the sample (Table 3) and 13% of respondents identified data gaps as an obstacle to more effective water policy (Table 5). Respondents asked for a more complete understanding of how much water exists by basin (including precipitation, runoff, infiltration, groundwater volume...), how much is appropriated in water rights, the paths of water flows (including through infrastructure), how water is used, and how it is reused. Many expressed incredulity that they were asked to manage water resources with poor baseline data, though others cautioned that data would never be as precise as policy makers and practitioners would like.

One-fifth of all respondents also called for more relevant, higher quality science (Table 5), believing there is sometimes a disconnect between information gaps and studies undertaken by universities. Integrating science into policy was also seen as a current weak point for 14% of respondents. On the one hand, it was suggested that scientists do not participate enough in the policy process; on the other hand, there is a fear that politics could interfere with the impartial scientific process. Despite these concerns, respondents expressed the desire to base decision-making more on science.

Crisis as Solution

"Necessity is a good driver."

Many of the solutions offered by respondents would entail an overhaul of California's current governance structure and approach to policymaking. For that reason, waiting for a crisis or catastrophe to force change was a 'strategy' that some respondents felt was necessary (Table 5). Others thought a crisis, whether real or perceived, was the *only* way major water policy change would occur in the state because problems related to governance structure and institutions are simply too entrenched. One respondent recommended to "never waste a good crisis." Another noted: "Australia had to experience a major drought to get people's mindsets to change. California is probably headed that same way."[22]

CONCLUSIONS AND POLICY RECOMMENDATIONS

"All our challenges are political, not technical."

This paper provides an overview of California's long-term water policy challenges and potential solutions from the perspective of leading water experts with varying backgrounds, goals, expertise, and regional viewpoints. It shows where there is general agreement on water problems and solutions, as well as instances where perceived problems and solutions vary by water sector. Overall, we found broad agreement that important aspects of water policy are not working well—such as management of the Sacramento–San Joaquin Delta, administration of the ESA, and management of the state's groundwater resources. Top water problems generally matched those described in water resource books and academic articles.

In these interviews, the importance of fixing the Delta was raised most often as one of the state's top water problems (Table 3). Focus on the Delta was

21 Legislation passed in 2001 (Senate Bills 221 and 610) require large developments (>500 units or involving more than a 10% increase in service area water demands) to demonstrate 20 years of reliable supplies. Federal law places restrictions on new development in areas designated as part of the "100-year floodplain," which is defined as at risk of being inundated by a flood with a 1% probability of occurring each year. Flood legislation passed in 2007 places some additional restrictions on future floodplain development in the Central Valley within the 200-year floodplain.

22 Reforms in Australia include major reductions in urban water use, an overhaul of water rights, and the creation of an active water market (Kendall 2011).

conspicuous across all water sectors (Table 4) and all parts of the state (representation from Northern and Southern California was approximately equal). This suggests that experts agree that the Delta's problems affect California as a whole in significant ways, even if they do not agree on the details of solutions. Despite the spate of recent lawsuits about the Delta, as well as the contentious congressional proposal (HR 1837) to remove all species-related restrictions on Delta pumping, interview responses indicate there is potential for compromise which addresses both economic and environmental concerns for this region. Such a compromise could involve the construction of new conveyance but exporters may need to accept less water from the Delta than they are now seeking, at least until fragile aquatic species recover. Export interests need to be reminded that new conveyance can provide value in terms of improved water reliability and water quality for both urban and agricultural sectors, even without substantial increases in water volumes, and environmental interests should bear in mind that without a reasonable level of exports, exporters may walk away from the deal, making it difficult to garner public support for investing in ecosystem rehabilitation (Lund and others 2010; Hanak and others 2011).

For the Delta and other distressed aquatic ecosystems in California, another potential area of common ground relates to concerns over implementation of the ESA and deteriorating aquatic ecosystems (Table 3). Those who thought water used for the ESA was wasteful and those who wanted stricter enforcement all believed environmental protection should be measured by ecosystem health rather than single species. This suggests room to find mutual agreement for measurable improvements in environmental protection (and perhaps better quantify environmental water use efficiency, including tracking where and how restoration dollars are spent). However, as some respondents pointed out, regulatory laws, such as the ESA, are ill-equipped to incorporate the flexibility needed to address climate change (as distributions of species and habitat types are anticipated to shift) (Parmesan and Yohe 2003; West and others 2009; Hanak and others 2011). This suggests the need for innovative approaches to develop long-term habitat conservation plans, with serious experimentation and adaptive management programs that do not "overnegotiate" all the details in advance (Lund and others 2011).

Groundwater management is another area of widespread concern. It has been 20 years since a frustrated Hundley (1992) wrote that groundwater is available for any pumper regardless of effect. Parts of California's Central Valley as well as the Central Coast provide textbook examples of groundwater overdraft (USGS 2009; Jury and Vaux 2005; MCWRA 2001; Hundley 1992). Local water users and agencies in these regions have resisted state intervention and have forgone adopting management models used in urban Southern California and the Silicon Valley, including adjudication and the creation of special management districts (Hanak 2003). Fortunately, some progress has been achieved in local basin management over the past 2 decades, with better local coordination and monitoring (ACWA 2011; Nelson 2012) and the development of formal groundwater banking arrangements, including extensive monitoring and mitigation in some areas (Thomas 2001; Hanak 2003). The path to more sustainable management may lie in the state's promoting continued local progress (with financial and regulatory incentives—the "carrots and sticks" approach some respondents mentioned in our survey). In addition, the state could use technological advances, such as improvements in the interpretation of remote sensing data, as a noninvasive (and perhaps more politically feasible) way of measuring groundwater use.[23]

Lack of public participation, politicians' aversion to risk, poor leadership, and stakeholders' unwillingness to compromise were all named as major factors that leave California to muddle through water problems. Proposed solutions generally relied more on cooperation, local innovation, and removal of regulatory obstacles. Commonly suggested solutions to address water supply scarcity—one of the major long-term

23 Advances in the interpretation of satellite imagery are facilitating crop water use estimation and estimation of groundwater basin depletion across the western United States. For information on the METRIC program used in many applications, see *http://www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm*. For information on the Sebal North America, Inc. program, see *http://www.sebal.us/*. See also MacEwan and others (2010).

problems identified—were appropriate for local and regional approaches. Although respondents listed numerous ways to augment supplies (water recycling, groundwater banking, desalination, and—for a few— new surface storage), the need to carefully manage existing supplies with increased water use efficiency and water transfers, was also a recurrent theme. California has made significant progress with the expansion of this "portfolio" of water solutions over the past few decades, such that total human water use today may now be lower than it was in the mid-1990s, despite continued population and economic growth (DWR 2009; Hanak and others 2011). Continued progress on these fronts can help reduce conflicts over management of water for the economy and the environment (Hanak and others 2011).

The relatively limited emphasis on new surface storage by all groups except politicians is noteworthy, given the often heated debates on this topic in the state legislature over the past decade. Politicians—and to some degree the public, which is approximately split between building new storage and more efficient use of existing supplies (Baldassare and others 2009)—are not on the same page on this topic as most California water experts, who do not consider expanding large surface storage projects as a priority to address current water-management problems. In contrast, numerous respondents recommended new conveyance infrastructure, both for Delta exports (to minimize conflicts between ecosystem goals, improve water supply reliability for export water users south of the Delta, and enhance water quality) and better cross-valley conveyance south of the Delta for east-to-west water transfers (given the relatively more abundant supplies in many communities on the east side of the San Joaquin Valley).

The Public Trust Doctrine and Reasonable and Beneficial Use Doctrine were mentioned by only a handful of respondents, but their comments are insightful and so we share them. With reasonable and beneficial water uses,[24] 5% of respondents thought the concept hazy to begin with, and felt it is inconsistently enforced. The public trust was mentioned in 10% of interviews, although respondents expressed confusion about how the SWRCB should "proceed from theory to doctrine."[25] There was broad agreement that the state has public trust responsibilities, but no clear process as to how to implement them. Respondents thought environmental water policy might be limited by a lack of clarity in how to apply these doctrines, views which have also been expressed in water policy academic papers (Sax 1980; Wilkinson 1989; Neuman 1998).

Respondents also discussed some novel ideas and regional approaches that could be used as models for California. For instance, the stewardship fees the Metropolitan Water District of Southern California charges were considered a potential model for generating stable revenue to support local water projects, as well as for better environmental stewardship. The IRWD was praised for creative water management, in particular the allocation-based tiered water rate structure used to promote conservation and reduce stormwater pollution that results from excess landscape irrigation. These water districts were also commended for maximizing the use of local water supplies, thereby reducing pressures on other watersheds. Likewise, the Kern Water Bank was the example nearly everyone used when they discussed groundwater banking and conjunctive use of surface and groundwater supplies. The California Coastal Commission was

24 The reasonable and beneficial use doctrine, which is set forth in Article X, Section 2 of the California Constitution, is a fundamental principle of California water rights law. All water use must be for a beneficial purpose and must be reasonable under the circumstances. The determination of reasonable use takes into account not only each water user's practices, but also broader considerations including water availability, potential conservation, and competing demands—both consumptive and environmental. A use of water that is reasonable under one set of conditions may become unreasonable as hydrologic, economic, demographic, and environmental conditions change over time (Hanak and others 2011).

25 "Public trust" refers to the legal recognition (under common law) that the state retains continuing supervisory control over all its navigable waters and the lands beneath them and must protect the public's common interest in them for navigation, commerce, fishing, recreation, preservation, and scientific study, except in the rare situation where the state has abandoned its rights consistent with those purposes. Following court decisions, the public trust has been explicitly held in California to apply to rights in flowing waters. See Box 1.3 in Hanak and others (2011).

cited as an agency that has successfully integrated water- and land-use planning in coastal regions. Similarly, the Department of Fish and Game's Marine Life Protection Act Initiative and Blue Ribbon Task Forces[26] provide models to integrate science into the decision-making and policy process without overreliance on particular special interests.

The experts interviewed for this study are water insiders and thus offer unique perspectives on water policy and management. Their responses show that there are areas of California water policy where beliefs converge on policy priorities and solutions. Areas of divergence are not surprising, but explicitly identifying them help us understand boundaries within policy coalitions, where policy tensions lie, and how differences may play out in the policy process. Many respondents highlighted innovative local water policy and management strategies that show promise for expansion to other parts of California. Interviewees also noted that California's ability to solve its water problems will be limited if the state lacks strong leadership or continues to avoid difficult changes and clings instead to dated approaches, such as dam building or compartmentalized water management.

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26 The Marine Life Protection Act, passed in 1999, requires California to reevaluate all existing Marine Protected Areas (MPAs) and potentially establish new MPAs, creating a systematic statewide network of protected areas. In 2004 DFG gained new funding to initiate the Marine Life Protection Act Initiative. The initiative divided the coast into sequential regions and assembled a Blue Ribbon Task Force on Marine Protected Area, Science Advisory Team, and Regional Stakeholder Group to develop and evaluate the first set of MPAs in the Central Coast region. To date, plans for the Central Coast and the North Coast have been adopted, and work is underway on a plan for Southern California.

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APPENDIX A: INTERVIEW RESPONDENTS

Curt Aikens
David Aladjem
John Andrew
Ernesto Avila
Paul Bartkiewicz
Naser Bateni
Thad Bettner
Alf Brandt
David Breninger
Byron Buck
Celeste Cantú
Michael Carlin
Tito Cervantes
Mike Chrisman
Francis Chung
Senator Dave Cogdill
Richard Roos–Collins
Congressman Jim Costa
Mark Cowin
Dennis Cushman
Cliff Dahm
Darryl Davis
Grant Davis
Martha Davis
Dan Dooley
Thomas Dunne
Hap Dunning
Mike Eaton
Marc Ebbin
Jim Fiedler
Randy Fiorini
Graham Fogg
Richard Frank
David Freyberg
Peter Frick
David Fullerton
Gerry Galloway
Greg Gartrell
Ron Gastelum
Jerry Gilbert
Brandon Goshi
Vicki Kretsinger Grabert
Les Grober
Kamyar Guivetchi
Doug Haaland
Les Harder
Thomas Harter
Mike Healey
Bruce Herbold
Phil Isenberg
Diana Jacobs
Paul Jones
Bill Kahrl
Randy Kanouse
Lillian Kawasaki
Dan Kelley
Jeff Kightlinger
Jerry King
Ken Kirby
Kevin Knuuti
Cliff Lee
John Leshy
Jeff Loux
Mark Lubell
Sam Luoma
Steve Macaulay
Clyde MacDonald
Bob Maddow
Einar Maisch
Steve McCarthy
Jerry Meral
Marvin Meyers
Ben Miller
B.J. Miller
John Mills
Dick Norgaard
Doug Obegi
Dennis O'Connor
Tim O'Halloran
Roger Patterson
Senator Fran Pavley
Jessica Pearson
Jason Peltier
Bill Phillimore
Nick Pinhey
Tim Quinn
Peter Rabbon
Betsy Rieke
Steve Ritchie
Justice Ron Robie
John Rossi
Leah Russin
Andy Sawyer
Monty Schmitt
Rita Schmidt Sudman
Will Stelle
Ron Stork
David Sunding
Peer Swan
Tina Swanson
Greg Thomas
Steve Thompson
Stu Townsley
Tim Washburn
Fran Spivy Weber
Vicky Whitney
Bob Wilkinson
Senator Lois Wolk
Jim Wunderman
Terry Young
David Zilberman
Anonymous (2)