Computer Aided Dispute Resolution (CADRe) Workshop

September 13-14, 2007
Albuquerque, NM

Objectives:

- *Define the domain of Computer Aided Dispute Resolution (CADRe)*
- *Share experiences / facilitate discussion among practitioners about CADRe practices and processes*
- *Set the stage for a forward looking strategy of CADRe capacity building*

Sponsors:

- *Institute for Water Resources, U.S. Army Corps of Engineers*
- *Sandia National Labs*
- *United States Institute for Environmental Conflict Resolution*

Computer Aided Dispute Resolution (CADRe) Workshop Agenda

Thursday, September 13th		
Time/ Room	**Session**	**Description**
9:00-9:15 Franciscan	**<u>Introductions and Workshop Objectives</u>** Hal Cardwell, Institute for Water Resources	
9:15-10:00 Franciscan	**<u>CADRe: Scope, and Challenges</u>** Leonard Shabman, Resources for the Future Kurt Stephenson, Virginia Tech	A presentation to introduce key themes and concepts for the workshop. Presenters will review the motivations for CADRe processes (conflict, decision-making fragmentation, science/policy tensions, etc). Next, a conceptual framework that highlights unique features of CADRe processes and differences in methods of "doing CADRe" is presented. The presentation concludes with the opportunities and challenges for CADRe. A companion discussion paper is included in workshop materials.
Franciscan	**<u>Origin, Evolution, and Motivation of CADRe</u>**	
10:00-10:15	***What I do, how I do it and why?*** Dan Sheer, Hydrologics	This session will bring together the early innovators to discuss how/why they came to their own approach to CADRe, describe what it is they do, and how it may have evolved during 20 years of experience. The session will compare and contrast their different approaches to computer-aided collaboration. A user of CADRe is included on the panel to provide the end-user's perspective on the value and challenges of what it is the panelists do. Time will also be reserved for questions from the audience.
10:15–10:30	***What I do, how I do it and why?*** Rick Palmer, University of Washington Bill Werick, Werick Creative Solutions	
10:30–10:45	**Break**	
10:45–11:45	***Origins, challenges and the future: A conversation with early innovators, long term practitioners, and clients of CADRe processes*** Panelists: Lisa Bourget, International Joint Commission Richard Palmer Dan Sheer Bill Werick Facilitators: Leonard Shabman Kurt Stephenson	

Time/ Room	Session	Description
11:45-1:00	**Lunch (Catered) –** Fireplace Rm.	
1:00-2:45	<u>**Case Study Forum: Round 1**</u>	
Franciscan	***A Comparison of the CADRe Process: Perspectives from the Gila, Rio Grande and Willamette.*** Vincent Tidwell, Principle Member of the Technical Staff, Sandia National Laboratories	Workshop participants will select two case studies to attend during each round. The case studies will be presented twice (in 45-minute sessions) in the round.
Potters	***Use of Modeling to Facilitate Interstate Collaboration on the Lower Susquehanna River.*** Thomas W. Beauduy, Deputy Director, and Andrew D. Dehoff, Director of Planning and Operations, Susquehanna River Basin Commission	The case study discussions will: (1) stress the intersection of technical models and decision participants, and (2) allow time for discussion and dialogue with those attending the case. Case study presenters are encouraged to bring materials to distribute. This forum is designed to encourage small group discussions about the case.
Weavers	***Role of Modeling in the Development of Interim Guidelines for the Operation of Lake Powell and Lake Mead.*** Carly Jerla, Hydraulic Engineer/Bureau of Reclamation – Lower Colorado Region	
Turquoise	***Climate Change and Water Planning in the Northwest.*** Richard Palmer, Professor of Civil and Environmental Engineering, University of Washington	
2:45 -3:15	**Break**	
3:15–5:00	<u>**Case Study Forum: Round 2**</u>	Short papers describing each case are included in workshop materials.
Franciscan	***Incorporating Modeling into Decision-Making for a Comprehensive Aquifer Management Plan – A Facilitator's Observations on Idaho's Eastern Snake Plain.*** Diane Tate, Program Manager, CDR Associates	
Potters	***Solving Urban Watershed Problems in Los Angeles through the Use of Collaborative Planning.*** Dan Rodrigo, Associate Partner, CDM	
Weavers	***Changing the Rules for Regulating Lake Ontario Levels.*** Bill Werick, Werick Creative Solutions	
Turquoise	***Drought Preparedness in Northern California – People, Practices, Principles and Perceptions.*** Ane Deister, General Manager, El Dorado Irrigation District	
5:30–6:30	<u>**Networking Reception**</u>	

Friday, September 14th

8:30 - 8:45 Franciscan

<u>Welcome, Plan for the Day</u>

Leonard Shabman and Kurt Stephenson

8:45-10:00 Franciscan

<u>Panel Interview</u>

What are the process challenges of CADRe?

Moderator and opening remarks:
Jim Creighton, Creighton and Creighton, Inc
Panelists :
Jerry Delli Priscoli, Institute for Water Resources
Diane Tate, CDR
David Purkey, Stockholm Environment Institute
Jay Lund, UC Davis

The panel consists of professionals with principal expertise either in group process or as modelers. The goal of this panel is to highlight integration challenges and opportunities. Questions may include:

- Are modelers troubled by, or do they perceive, a limited rigor and objectivity in processes that rely on stakeholder consensus?
- Are stakeholders troubled by, or do they perceive a limited utility of complex and “black box” models for decision making?
- What are the challenges of avoiding building unrecognized “value bias” into model construction (reference conditions, risk preferences, etc.)?

10:00-10:15 **Break**

10:15-11:30 Franciscan

<u>Panel Discussion</u>

Agency Perspectives: Opportunities and Challenges for Increased Use of CADRe Processes

Moderator and opening remarks:
Kirk Emerson, USIECR

Panelists:
Peter Evans, Interstate Council on Water Policy
Rick Miles, Federal Energy Regulatory Commission
Chandler Peter, U.S. Army Corps of Engineers
Stan Ponce, U.S. Geological Survey

The goal of this panel is to identify and discuss the reality of agency missions and decision practices that create opportunities and challenges to agency staff in using CADRe processes. The panel consists of agency staff who are familiar with CADRe, may have used it, and are senior decision-makers in their agencies. Topics may include:

- Perceived benefits of integrating environmental conflict resolution, collaborative problem-solving, and computer-assisted decision support tools
- Barriers to agency participation in collaborative CADRe processes
- Lessons learned from agency experiences with collaborative processes–with & without use of CADRe

Time/ Room	Session	Description
	<u>**Call to Action: Refining and Advancing CADRe**</u>	This session is *critical* for achieving the following goals of the workshop: • better defining the domain of CADRe to promote a long-term community of interest and practitioners • identifying knowledge and expertise gaps and ways to fill them through education and training • developing outreach activities so that CADRe processes are more widely or effectively employed in water resource decision-making. Through a series of self-organizing discussion forum, beginning with a working lunch, all workshop attendees will be asked to address these themes, as well as other issues, concerns or opportunities that emerged during the workshop. By doing so, participants will identify next steps and action items for refining and advancing CADRe.
11:30-11:50 Franciscan	***Setting a Plan & Determining Topics*** Len Shabman and Kurt Stephenson	
11:50-12:15	***Break and Get Box Lunch***	
12:15-1:15 Franciscan Potters Weavers Turquoise	***Open Space Discussion Forums*** Jim Creighton All participants take a box lunch to the breakout rooms	
1:15 – 3:00 Franciscan	***Fish Bowl*** *(Break included)*	
3:00 – 3:30	<u>**Commitments and Plans for the Future**</u> Erik Webb, Office of U.S. Senator Pete Domenici Hal Cardwell	

Overview and Discussion Paper

Computer-Aided Dispute Resolution: Approach and Evaluation

Kurt Stephenson
Virginia Tech

Leonard Shabman
Resources for the Future

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I. Introduction

Computer-aided dispute resolution (CADRe) is an approach to decision making that supports negotiation among disagreeing parties with computer simulation models. Although the acronym CADRe, for computer-aided dispute resolution, is used here, the approach has no single formal name, no single disciplinary origin, and no professional associations (See Box 1). CADRe refers to various, largely independent and isolated efforts to integrate two rapidly growing, but largely distinct approaches to decision-making: negotiation / bargaining as a means of resolving water resource decision making disputes and development of computer based systems models intended to support water resource management negotiations.

The term computer-aided dispute resolution (CADRe) reflects the blending of these two approaches to decision making. Dispute resolution (DRe) makes reference to processes of negotiation and bargaining as a means for making water resources and environmental decisions. Computer aided (CA) makes reference to computer simulation models – and perhaps visualization – to predict outcomes (or performance) of different actions taken to manage water or human behaviors in a watershed.

The first body of research and related practice focuses on governance systems and conflict resolution. Mediation professionals publish literature on how to design and conduct multi-stakeholder negotiations (Susskind, McKearnan and Thomas-Larmer 1999). An element of this literature also studies and assesses the conditions and barriers to successful negotiations (Wondolleck and Yaffee; Koontz et al.; O'Leary and Bingham; Coglianese; Bauer and Randolph). The literature extends to the normative question of which stakeholders should be party to the negotiation. Various government agencies' programs and environmental management initiatives are organized with collaborative decision-making as their central theme. The second and largely independent body of work seeks to inform decision making with computer simulation tools that manipulate and interpret data in order to predict the relationship between selection of any alternative and attainment of different goals. These simulations allow stakeholders in a negotiation to ask "what-if" questions and get answers, without taking action in the real world environment. Simulation models can be high or low resolution and can be expensive and time consuming to build or low cost to develop. The computational algorithms in simulation models can be transparent or opaque to the parties to the negotiation, but are always fully understood by the model developer.

Surprisingly little overlap exists between the two areas of work. The research and practitioners exist separate from each other and the work in one area rarely influences the work in the other. Some of the negotiation literature focuses on "joint-fact" finding and seeking agreement on technical information (Adler et al.,; Bingham 2003; Ehrmann and Stinson 1999). However, ways in which computer simulation models can be used to synthesize scientific information, illuminate the functioning of complex systems, and facilitate the search and evaluation of alternatives in collaborative processes has drawn relatively little attention from these professionals.

Box 1: CADRe

Computer aided dispute resolution (CADRe), as a broad approach to water resource decision-making, has also been called shared vision planning (SVP), computer-aided negotiation (CAN), mediated modeling, stakeholder assisted modeling, and group model building. All this work seeks to explicitly integrate technical computer modeling into group problem solving. Each has developed different implementation approaches, been applied to different problem contexts (water resources, ecosystem management, air emissions/climate change, corporate management, etc) and used for different decision purposes (visioning exercises, planning processes, and negotiated decision-making). Collaborative computer model building can be used for reaching agreement on a long term vision for a watershed and on setting long term goals to guide future decision making. Parties can disagree on a vision or on a plan, but disagreements often can be resolved by modifying the plan to make all better off, especially if the vision or plan requires no immediate regulatory or budget decision.

Modeling can also support the making a decision that will lead to a specific regulatory and/or budget decision with consequences for decision participants. It is most likely that disagreements that are most difficult to resolve will arise when the decision reached will have real and immediate consequences for one or more decision participants. Hence the focus of this workshop is on computer simulation modeling as an aid to resolution of disputes with immediate resource consequences.

It is also true that the computer simulation literature often begins with the presumption that a water resource choice deals with inherently complex and interrelated systems that are populated with multiple stakeholders with competing positions. However, the analytical tools are often developed as if there is a well defined decision-maker (social planner, government agency) who has trust in the model and the authority to make a choice among various alternatives.

Bringing "CA" together with "DRe" means asking: "how can, and when will, simulation modeling add value, in relation to cost, to a negotiation process for resolving a water resources dispute?" That is the question for this workshop and is the principal focus of this background paper. The implicit premise of the framing of the question is that negotiation processes for decision making/ dispute resolution are preferred, at least in some places and for some situations. Furthermore, we initially define the "success" of negotiated decision making as reaching agreement on a course of action among the stakeholders to a dispute. We are aware that there can be criticism of this success definition and challenges to whether the definition equates with – or will yield – decisions in the "public interest." We will return to that question in the last section of the paper.

It is argued here there is no single way or single approach to bringing CA to DRe. We do not propose that the domain of CADRe be carefully circumscribed or limited with a precise definition. Broad outlines, however, can be used delineate CADRe from other approaches to water resources decision-making.

First, the collaborative process literature often assumes technical knowledge and models are given from outside experts (who are in agreement on "the science") and the focus becomes how to organize participants and structure discussions to reach agreement or manage conflict. In contrast, CADRe processes integrate the development of computer based models of the water resource system into the negotiation process. While the word "model" may be used to describe a variety of constructs (mental models, conceptual frameworks, theoretical constructs), the use here refers to computer programs that predict key physical, biological and economic elements of the water resource system. Such models distinguish CADRe processes from other negotiated situations that either rely on existing knowledge or jointly develop common technical and scientific backgrounds (e.g. joint fact finding, collaborative science)

Second, within a CADRe processes, models must be explicitly designed in conjunction with the negotiation based decision processes. The convener of the negotiation organizes the participants to facilitate joint discussions based on the principles and practices described in the collaborative process literature. The CADRe modeling can then begin from an appreciation of the values, interests and analytical needs of the multiple participants to the negotiation. Models are explicitly designed in conjunction with stakeholder negotiations, but the models also meet the technical and professional standards of constructing a logically consistent and valid model. This coordinated development separates CADRe modeling processes from a significant portion of the technical water resources modeling literature.

Third, within CADRe, decision participants rely on the model(s) as a focal point for their conversations. In this sense, the commonly agreed upon technical models serve a role analogous to the single text negotiation tool from which decision participants can organize their collective deliberations. The models are an integral way through which decision participants communicate with each other and discuss relationships within the water resource system. The conversation through the model is the way that alternatives are discovered, debated, and decided upon.

Finally, we offer that that CADRe is built on a specific behavioral perspective on human decision-making. Specifically:

- CADRe accepts the basic premise of collaboration literature that learning and discovery are the key to reaching consensus for decision making. Rarely are all alternatives or options known in advance.
- CADRe begins with a premise that knowledge is fragmented among the decision participants and there is a limited ability of any participant to comprehend and understand all the relationships with the complex system (Lindblom 1990; March 1982). CADRe computer simulation models and group collaboration can facilitate a broader and shared understanding of system relationships and consequences.
- CADRe begins with the basic premise that decision-making through learning is iterative because stakeholder preferences are developed or discovered when confronting choices (Vatn and Bromley 1994). Psychological research provides substantial evidence that preferences for outcomes are contingent on past experiences and an understanding of existing alternatives. With the discovery and creation of new alternatives and choices, preferences change and evolve.
- Existing regulations, organizational routines, and individual habits of thought simplify day-to-day decision-making, but can also limit consideration or awareness of opportunities beyond what currently exists.

- Given points above, CADRe accepts the premise that opportunities exist for discovering alternatives and options that can improve and advance the interests of all decision participants (called integrative bargaining)
- CADRe assumes that science and technical analysis cannot stand alone from policy and should be at the service of decision-making. Science and technical analysis is critical to aid in the understanding of biological, physical, and economic consequences of different alternatives, but must be responsive to the needs of decision participants. Models and technical analysts should not presuppose what information participants need or dictate (intentionally or unintentionally) the selection of alternatives.
- Decision-making is not strictly an analytical exercise. Group learning and shared experiences can build social relationships between people. The development of social capital between multiple and competing decision participants facilitates integrative bargaining. As noted by Majone (1992, page 9) "… persuasion is a two way interchange, a method of mutual learning through discourse. Real debate not only lets the participants promote their own views and interests, but also encourages them to adjust their views of reality and even to change their values in the process. … Fashioning mutual understanding of the boundaries of the possible in public policy is arguably the most important contribution that analysts can make to public debate."

Within these broad outlines, a variety of approaches and applications in the literature could be classified as CADRe (examples include Sheer et al. 1989; National Drought Study 1993; Frederick et al 1998; Tidwell et al. 2002; Tate 2002; Carmichael et al 2004; van den Belt, 2004; Mostashari and Sussman; Palmer 2007). It is argued here that different CADRe processes cannot and should not be distinguished based on the type of software or technical water resource model used (Box 2). Nor should there be an effort to define the domain of CADRe beyond the broad outlines described above. Each CADRe process can and should be different depending on the problem being confronted, the level and source of conflict, and analytical needs of the parties to the negotiation.

Box 2: Analytical Models and CADRe.

CADRe is not defined with reference to a specific computer simulation model. Nor are technical models with a graphical, interactive computer interfaces necessarily CADRe models or even necessary to CADRe. A substantial literature on decision support system exists. Decision support systems are intended to aid decision-making by making the model more accessible to decision participants. Yet, decision support systems are sometime developed independent of any decision process and for a generic decision-maker. Decision support systems that are not integrated into a collaborative process should not be labeled CADRe.

Similarly, CADRe processes are not defined by the type of computer simulation model used. A variety of computer simulation models have developed for water resources planning. Such models include OASIS, MODSIM, RIVERWARE, WATERWARE, WEAP (see Tate for a summary). Features of such software systems may support CADRe processes, but software alone cannot define CADRe. As discussed below, CADRe is defined here based on how and whether technical models are used and integrated in a collaborative process.

Rather, this paper proposes a way to describe CADRe oriented process based on the types and forms of *integration* between technical models and collaborative processes. Three different levels of CA to DR integration are described. At each level, a number of different approaches to integration are described along with questions regarding how such integration can occur. The next section includes a taxonomy of the causes of conflict in water resources, conflicts that some say have led to “gridlock” in contemporary water resources decision making (Stakhiv, 20XX). As noted, we accept, as do many others, that negotiation is one way to reduce this gridlock. We conclude with a discussion of issues and challenges that confront the successful application CADRe with contemporary water resource policy.

Finally, the purpose of this background paper is to guide and stimulate discussion at the workshop. Toward that end, the paper poses questions in italics for discussion, or at least for consideration by the reader, at numerous places in the text. The first of these questions follows:

> *Question for Discussion: Is it necessary to define the boundaries of CADRe in order to develop a professional community of researchers and practitioners and initiate a conversation within that community of the “best practices”, definitions of success or other matters?*

II. Setting the Stage for CADRe

In recent decades there has been a diffusion of water resources decision authority away from the large and centralized bureaucracies toward multiple agencies of governments, each expected to exercise some decision making responsibility for how water and related land resources of a watershed should be managed. Meanwhile laws passed in the 1970s such as the Clean Water Act and Endangered Species Act have given standing to non–governmental organizations to significantly influence water allocation, use and management. These organizations may align with the agencies most compatible with their position or may remain outside any agency process, but be empowered by their ability to appeal to political or judicial processes to secure decisions consistent with their preferences (Kingdon and Sabatier; Sabatier and Jenkins-Smith 1993). Add to this reality that in many situations there is no clarity of where decision making authority resides. Instead, every decision may have to pass through layers of review and appeal, often without a clear point where all the considerations are brought together, weighed and a final decision made (Shabman and Cox, 2004). In this contemporary setting of shared decision making authority, decision making means managing conflict. CADRe is offered as one method of conflict management. William Lord (1979) defined three sources of conflicts over water management: “value,” interest,” and “cognitive.” We add to this list the diffusion of decision-making power and influence and call this “authority conflict.”

> *Question for Discussion: If CADRe is about managing conflict, and agencies are part of the conflicting partiers, then who is to be the conflict manager? This is a topic considered in the last section.*

Interest conflict

Interest conflict arises when a decision will have different effects on different groups and the affected groups can effectively voice their support or opposition to the proposed decision. Interest conflict is related to how an alternative will personally influence private stakeholder interests (Lord 1979). For example, a proposed water supply project of one local community may reduce future water supply of a downstream community. In this case the water supply decisions are perceived to have a direct impact on the economic well-being of a downstream community. Interest conflict may arise when an existing benefit (ex. Water for irrigation or navigation) is threatened by the new emphasis on mimicking historic flow regimes on a river.

Resolution of interest conflict will occur either through bargaining and compensation to those harmed or through the exercise of power of one stakeholder over another. Economic mitigation (cash compensation payments) are a long standing form of compensation for harmed interests. Environmental mitigation requirements in current laws are a form of compensation for the public.

CADRe process will identify opportunities for identification of alternatives leading to mutually beneficial outcomes or compensation of losses (real or perceived) of the parties to the negotiation. CADRe provides a process of finding solutions that provide positive net benefits to all parties, so that in the end all participants find benefit in the solution. CADRe can also quantify the loss so that it can be indemnified.

> *Question for Discussion: Is the identification of ways to "make the pie bigger" so all may have positive net benefits (termed integrative bargaining) something that can be most readily facilitated with CADRe?*

Value conflict

Value conflict arises over different opinions of what is good for us as a community or society rather than what is good for me the individual (Lord 1979). "Value" conflict can be more abstract and subjective than interest conflict. In water resources value conflict often centers on the relative importance of maintaining environmental conditions, or restoration of past conditions versus protecting individual discretion (e.g. protecting water users discretion on how to use water) or accommodating population growth. Indeed, in the contemporary setting many water management conflicts can be traced to value conflict.

Sometimes strongly held values within a broadly defined stakeholder group may come into conflict in the context of a single decision. For example, environmental stakeholders may confront a reservoir re-operation decision that will benefit habitat downstream of the structure, but may inundate habitat upstream of the structure. Few may have a direct personal stake in changes in flow regimes (unless you are a boater, rafter, or angler your self interest may not be directly influenced by stream flow levels). Nonetheless, conflict over what instream flow ought to be can be acute.

Although resolution of value conflicts may be facilitated by inter-group communication, Lord argues that “value conflicts are [often] resolved by a unilateral (authoritarian) or collective (democratic) choice, in which one view prevails over the other . . . ” (Lord, 1979). A well structured CADRe process will help articulate these value-based choices and trade-offs.

> *Question for Discussion: Will the clarity of choices and tradeoffs among competing values, if highlighted in the CADRe process, help to resolve value conflict? Or, is it unlikely that intense value conflicts can be resolved through mutual agreement within the CADRe process.*

Cognitive conflict

Cognitive conflicts are over the data, analysis, and models used to characterize problems, their possible solutions and consequences of different choices that may be made. For example, groups may have different perceptions of the effect of increased water withdrawals upon lake levels or on the legality of water withdrawals. Lord (1979) calls these technical debates “cognitive” conflict. Better knowledge and more sophisticated technical analysis can reduce this type of conflict.

Resolving or managing cognitive conflict is challenging, given the complexity of our natural and social systems and the forward-looking nature of the planning process (what is and what will be). For example, technical analysis of existing technologies and water use behaviors can better inform, but rarely provide a definitive answer to, what per capita water consumption or population growth in a region is likely to be in the future.

The traditional approach to resolution of cognitive conflict is to call on technical experts who would provide answers to questions posed to them. Then decision makers would accept the expert assessment and make choices related to matters of interest and values.

However, today technical expertise itself is not a monolith. There has been the rapid expansion of the disciplines and tools for analysis of what might be broadly termed environmental sciences, where once only water engineers were looked to as experts. Expertise is divided along more than just along broad disciplinary lines – engineering, economics, ecology, law. For example, there is a whole sub-discipline of wetlands science that holds its own professional meetings and has its own peer reviewed journal. This trend has infiltrated the social sciences as well. For example, the economics profession has a subgroup of experts whose attention is devoted almost entirely to tools for estimating money-equivalent values of services of natural capital. As multiple disciplines, and the sub disciplines has grown, the number of “experts” has grown, differences among experts within and between disciplines have become common. No agency can (relative to past years) make a claim of having the most or the best technical experts.

On top of this, there has been a changing public acceptance of the role of expertise and a resistance to accepting the analysis of any single expert as definitive and objective. Suspicion of experts blossomed as widespread phenomena in the late 1960s and soon translated into a suspicion of government employees as experts, leading to suspicions of centralized or technical knowledge (Lach and Ingram 2005, 11). Today, parties with stake in an outcome may not accept the technical arguments of government or other experts without some form of external verification (consider the push for peer review of Corps reports in the current WRDA bill). At the same time claims to have expertise and “sound science’ on the side of your argument is still a significant advantage in any deliberation (Tarlock, 2003).

Question for Discussion: In general, cognitive conflicts are resolved when agreement is reached on the models and data used for analysis and the execution of the analysis is open to inspection. That is the domain and purpose of the CA modeling to support CADRe. Is it more likely that agreement can be reached upon cognitive conflicts than value or interest conflicts? How important is successful management of cognitive conflicts to productive dialogue and debate over other types of conflict?

Authority conflict

United States water resources decision-making is often described as if it were the product of the formal distribution of intergovernmental and intra governmental decision making responsibilities among executive branch officers and agencies, the legislatures, and the courts. However, these formal relationships alone do not fully characterize the locus of responsibility for making water management decisions. No agency at any level of government has final decision authority and competing authorities exist between and within levels of government. Also, coalitions form that will support the primacy of different agencies’ authorities (Sabatier and Jenkins-Smith, 1993).

This diffusion of formal and informal authority to decide or to review and possibly veto decisions of another accelerated in the 1970s with the rapid expansion of laws and regulations affecting water resources (e.g., ESA, CWA, NEPA). These new laws and regulations empowered different federal agencies and citizens to exert influence on water and related resources decisions in new ways, and often reflecting different value positions. This diffusion of authorities followed logically from the changing view of national water management goals. In addition, the 1970s environmental laws brought new opportunities for citizen standing to sue, as a form of check and balance on the exercise of discretion by a water management agencies who were promoting traditional development programs (Noble, 2002).

Decentralized governance is how one author describes the current situation (Peter Rogers), while others refer to civic environmentalism (Landy and Rubin 2001), or to the democratization of environmental decision making (Ingram). Whatever the term, and whatever its result, there is a need to satisfy many stakeholders because each is empowered by some law to advance its values and interests in administrative and legal arenas.

Incorporating affected groups and individuals into a planning process (for example, through formation of citizen or agency advisory committees) is becoming more common as a result. Assembling all affected interests having some measure of decision authority may aid in identifying and reconciling some sources of conflict during the decision-making process, thus avoiding future delays and lawsuits. However, often these many publics and many agencies represent and argue for inherently conflicting and irreconcilable water project development or project operation decisions and assert that they have primacy for making the final decision.

Question for Discussion: Integrating simulation models with negotiated decision making is the essence of CADRe. How will agencies view participation in a CADRe process given multiple and conflicting authorities? Are there specific practical methods (process and/or technical models) will help decision makers to resolve their "authority conflicts" as well as interest, value and cognitive conflicts?

III. Bringing CA to DR: Three Levels of Integration

Conceptually, integration of CA with DRe can occur on three different levels: model development, stakeholder objectives and modeled output, and technical support of collaborative negotiations. While it is recognized that individual CADRe processes will need to mesh CA and DRe at all levels, each type of integration will be discussed separately in order to develop a framework for comparing and discussing the challenges and approaches to CADRe.

Building a Model Credible to Decision Participants

Model construction for CADRe includes the same elements of any model building process: conceptual model development, defining technical relationships and response functions between model variables, and identification and selection of data inputs. Assume for the moment that selection of the model boundaries, objectives, and output are known and agreed upon (these will be discussed in the next section). Even if stakeholders agree on model purpose and outputs, integration occurs when decision participants gain confidence and understanding that the model produces a reasonable, credible, and ultimately an acceptable depiction of the system (as agreed upon by participants). This section focuses on the process of constructing technical models in a collaborative setting, including approaches and challenges of translating data, stakeholder knowledge, scientific expertise and relationships into computer models of the system. The goal of this level of integration is to construct a model that multiple, competing stakeholders jointly believe is an acceptable and trusted representation of the system.

This process provides a forum for decision-participants to share knowledge and information and enhance joint understanding of relationships within the system. Conventional modeling approaches envision the role of the scientist and technical modeler as providing analysis and models to the decision-makers. CADRe approaches allow the possibility that system understanding and supporting data can also be provided from decision-participants to modelers. At the same time, collaborative model construction facilitates additional understanding and appreciation of the knowledge and expertise *among* stakeholders.

Of special importance, the process of developing a common technical model also provides the opportunity to identify and manage technical and scientific disagreements and to avoid an end state described as adversarial science (Busenberg 1999; Ozawa 1991). Collaboration at this level is a way to manage cognitive conflict and overcome suspicion of centralized knowledge or perceptions of stakeholder information/knowledge bias. In many ways this level of integration forms the foundation for the CADRe process – if stakeholders cannot develop a jointly acceptable technical foundation for the collaborative decisions and negotiation, a CADRe process cannot achieve agreement on interest, value and authority conflicts. Multiple issues surround the process of building stakeholder acceptance of the technical model(s). How those design issues are addressed varies across applications and practitioners.

First, all negotiations must organize processes by which various decision participants negotiate and communicate with each other. These general process considerations include the level and type of participation among multiple and competing stakeholder groups and agencies, establishing the ground rules for participation, and facilitating communication between and among multiple groups. In developing CADRe technical models, the same issues must be addressed with respect to decision participants and technical modelers.

Beyond these kinds of requirements, there must be some consideration of the technical expertise of the participants. In many situations, decision participants do not have technical expertise to actually construct a model themselves. Yet, their participation may be necessary to build confidence and understanding of the model. Some processes stress the direct engagement where a third party modeler constructs basic elements of the model in the presence of decision participants (van den Belt 2004). This process might be simplified if decision participants communicate through a neutral and agreed upon technical modeling expert(s). The expert would solicit direct input from stakeholders, but would work off-line to develop the actual computer model (Hydrologics). In other instances, a subgroup of technical experts may be formed that direct or conduct the technical models. This subgroup could include modelers sent by competing stakeholder groups to represent their specific interests. This subgroup would be directed and report back to the stakeholder (management or policy) group responsible for decision-making (Werick and Whipple 1994; Call 2004).

The level and type of involvement stakeholder groups should have with the generation of data and the development of technical relationships and response functions must be addressed. Most CADRe processes develop some process for decision participants to contribute and discuss data inputs. Variations occur in interfacing with decision-participants with the development of technical relationships and response functions within the model. At the end of engagement, technical modelers and decision participants would develop (through one of the processes described above) the technical model from the ground up. This would include identifying how system elements are related to each other as well as developing the quantitative response functions within the system. The use of object oriented system software such as Stella is often used to construct such models due to the visually appealing and transparent way elements are connected in the system (van den Belt 2004; Werick and Whipple 1994). Case specific models could also be constructed based on a shared understanding of how general system elements are related (between decision participants and modelers) but the specific technical relationships would be developed by the model experts. Other processes may rely on preexisting programs that already have basic model system structure and algorithms already established.

> *Questions for Discussion: What are risks to the CADRe model development process of not engaging all interested parties in model development? How are the risks to be weighed against the time and delay costs of that engagement? Can modeler reputation substitute for group model building in gaining model credibility for a CADRe process?*

A second challenge to model development within CADRe processes is to anticipate and address cognitive conflict and uncertainty among scientific experts and possibly between experts and nontechnical stakeholders. Technical models for CADRe are constructed on assumptions of how the relevant water resource system under consideration operates. Those technical assumptions are in turn based on scientific studies and analytical constructs from the physical, biological and social sciences. The results from these studies may be either in dispute and/or subject to significant uncertainty. For example, the returning adults of a migratory fish species may be central concern stakeholders. Yet, understanding the role of changing water quality or timing/duration/magnitude of flow levels on fish population is typically subject to considerable scientific uncertainty and perhaps professional disagreements.

How and whether such disputed or uncertain response relationships are included in a technical model is an important design challenge of CADRe. Various options might exist to address scientific/technical uncertainty and conflict including conducting additional site specific field studies, additional collaborative fact-finding, soliciting expert judgments to identify bounded response functions, or developing acceptable, more identifiable surrogate responses relationships (for example, estimating of aquatic habitat rather than fish response). Gregory and Failing (2004) report opposition from scientific experts and stakeholders on getting expert judgment processes when data quality/scientific information is low.

> *Question for Discussion: What are the ways to anticipate and then mediate disputes among experts about the processes represented in the CADRe model or the data used in the model?*

Third, CADRe technical models must be designed to improve decision participants' understanding of the problem, and ultimately to use the model to assist in the identification and discussion of alternatives. A range of model features have been identified that would result in that use.

All technical modelers undertake standard procedures for calibrating and verifying technical models. Such tests provide checks on the internal consistency of the model and predictive adequacy of model outputs. Within CADRe processes, another layer of verification might occur with decision participants. Decision participants may have opinions on the adequacy of response functions and adequacy of model outputs. If decision participants do not have confidence the model adequately represents the system of concern, CADRe models are of limited value.

For example, model architecture that is *transparent* to decision participants (or their technical representatives) can facilitate stakeholder confirmation and verification data and technical relationships. Technical models that are capable of being modified or expanded can accommodate evolving stakeholder knowledge and interest. Indeed, model *flexibility* may be critical given the nature of collaborative process (group learning and discovery). Finally, technical models that are understandable to decision participants may be important to developing acceptable and trusted models. Such understanding does not necessarily mean knowledge of the technical mechanics of the model, but rather the general ways the model elements are related to each other and how model output is produced. The inability of stakeholders to comprehend technical models has been cited as a major barrier to refinement and acceptance (Sheer, et al 1989).

Questions for Discussion: What procedures or model characteristics contribute to decision participants' trust and confidence CADRe models and model results?

These features present special challenges to technical models in a DRe context. Technical models are all expected to be capable of "accurately" representing how the water resource system works. Modelers may wish to increase model complexity to better model system response functions. However, highly complex models will reduce transparency and understanding (Roach and Tidwell 2007).

Questions for Discussion: Increased complexity may not serve to increase predictive accuracy, although the lack of correlation between complexity and prediction accuracy may not be fully understood. How can inevitable model prediction uncertainty, as well as scientific uncertainty, be recognized and be made a part of a decision process based on negotiation? How can the model developers keep requests for more study and/or more detail from creating frustration with delay and costs of a CADRe process?

Building a Model Useful to Decision Participants

A second level for integration of CA with DRe concerns how stakeholder interests and concerns are reflected in the technical models. This integration includes both model objective/structure and model outputs. CADRe processes require that the modeling objective (model boundaries, what questions are addressed, what response functions are included) are responsive to interests of decision-participants, not based on the questions of interest to the modelers. The purpose of integrating technical models with collaborative processes is to create useable knowledge *for decision participants.* Therefore models must not only ask the questions that reflect stakeholder concerns, but also must produce answers as model outputs that are meaningful and accessible to multiple and perhaps nontechnical decision participants.

While establishing technical "if this … then that" relationships are the domain of technical analysis, the questions the relationships are designed to describe should be guided by participants and should seek to address sources of conflict among the participants. The distinction is often difficult to maintain and identify. For example, the objective of one stakeholder group might be to maximize some biological measure of the status of a particular fish species. This interest might ask the question, "What is the timing, magnitude and duration of water flow need to produce a healthy fish (or sustainable) fishery for species X?" Framing the problem in such a way requires the technical analysts and modelers to define "healthy" and "sustainable." Modeling becomes centered around trying to answer these questions, but both definitions are ultimately policy questions (Lackey, 2007).

What the model should answer is this question: "How will a population of fish species X respond to different water flows (magnitude, timing, and duration)?" This framing of the question focuses modeling attention on the stakeholder interest, but will rely on the decision participants themselves to define what constitutes a "healthy" or "sustainable" fishery. Furthermore, the search and identification of imbedded model assumptions and model structures that circumvent or obscure policy choices also requires coordination and communication between technical modelers and process facilitators (if different parties). Helen Ingram and Anne Schneider (1999, 27) state that “the most fundamental flaw in contemporary water policy is that many value questions in which ordinary citizens have a great interest are being framed as technical questions.”

> *Question for discussion: How can facilitators and technical modelers participating in CADRe process avoid tendencies to embed policy questions within the technical analysis? How can value neutrality of analysts and process facilitators be maintained?*

CADRe processes also recognize that decision participants also often enter policy with both vaguely formed notions of the scope and nature of the problem being confronted and their own specific interests and values (Simonovic and Bender 1996). Unstructured problems mean that boundaries and objectives of the model may shift and be refined over the course of the negotiation. Models and modelers in CADRe processes must be in a position to both accommodate ***and*** facilitate the developing knowledge of the decision participants about their own preferences and interests.

However, the most effective processes will not just frame questions responsive to stakeholder interests but must also produce answers in a form useful to stakeholders if they are going to be effective participants in dynamic, iterative negotiations. The burgeoning literature on ecological indicators, for instance, focuses on indicators produced for and by scientists and neglects the use and importance to policy and management (Turnhout et al 2007). To be useful to stakeholders, a variety of criteria have been proposed for model outputs (performance metrics, indicators, etc.) including whether the outputs are credible, meaningful, representative, and relevant for decision participants (Gregory and Failing). In fact, indicators must emerge from a collaborative process, cannot always be defined in advance or in isolation, and in the best case, will be refined as the collaborative process goes on.

Due to differences in technical expertise and professional orientation, the utility of performance metrics will not coincide perfectly among technical modelers, scientific experts, and stakeholders. For instance, risk and uncertainty are expressed and understood very differently between risk experts and nontechnical people (National Research Council 1996). Thus facilitators and model experts may have to investigate ways to translate measures of risk and model uncertainty in ways that are accessible and meaningful to stakeholders. Subtle phrasing of indicators could also influence the acceptability of a performance metric. For example, the implied baseline of a performance metric could be of critical importance. In one case, expressing risk of flooding as probability of flooding was found to inhibit negotiation while expressing the same notion as the reduction in the chance of flooding from the status quo condition generated more productive discussions (Gregory and Failing). The expression of probability focused stakeholder attention on how far an alternative was from what was considered an ideal (zero probability of flood risk) while flood risk reduction stressed the amount of improvement.

Identifying measurable indicators that are predictable from the model structure with some degree of certainty is often cited as an important criterion for a performance metric (Sheer 1989;

Gregory and Failing). A CADRe process that pushes decision participants to articulate, identify, and then agree on specific performance metrics is important to reaching agreement on a decision in a CADRe process. Just as important, however, the process of developing identifiable performance metrics is a learning process itself, requiring stakeholders to narrow and sharpen their own thinking about what aspects of the problem are important and critical to their interests and values.

Practitioners of CADRe processes, however, are confronted with challenges and trade-offs in developing credible and useful performance metrics. Many stakeholder objectives may not be readily translated into measurable output. Stakeholder objectives may be based on deeply felt but intangible or subjective values and beliefs (Sheer et al. 1989). While such values may be difficult to quantify articulation and incorporation of such values are central to most problems and an essential requirement of any evaluation (Lord; Ingram; Sheer et al.*1989).*

Various decision participants may insist or require the development of different performance metrics and multiple metrics may not be useful or create conflict among different stakeholders. For example, agencies may require specific types of analysis and metrics as part of a decision processes. These agencies may insist that such metrics should become an integral part of a collaborative process even if other participants believe that such metrics are either unnecessary or detrimental to negotiations. In other cases, agencies may wish to avoid certain outcome metrics because they are beyond their perceived regulatory authorities.

Furthermore, in complex, multi-objective water resource problems, a multitude of different performance metrics could be developed. These metrics will in all likelihood be expressed in different units (dollars, flows, habitat, probabilities, etc). Adding performance metrics may more accurately represent dimensions of the problem important to stakeholders, but can increase the challenge of the collaborative process to sort and compare alternatives (see next section).

> *Question for discussion: Given the fundamental importance but measurement challenges, how should metrics for representing performance of alternatives be developed in a CADRe process?*

Building and Using a Model to Reach Agreement

Simulation models in a CADRe process are used for negotiating over, and deciding among, alternatives. More specifically the accepted models and model outputs are the venue and vehicle for multiple and competing groups to communicate with each other. That communication through the models allows decision participants to refine their own values, interests and acceptable tradeoffs while also learning the same about others. This level of integration facilitates the development and discovery of more satisfactory alternatives through low cost experimentation of playing “what if” exercises with the technical models (Sheer et al 1989, Werick and Wipple 1994; Reitsma et al. 1996).

The goal of this level of integration is for multiple and competing decision participants to effectively use technical models to discover, create, and evaluate alternatives and then decide among alternatives. This use of the model can assist in reaching agreements in two ways. One way is to test the sensitivity of the model solution to input data or other factors that might be in dispute. Given scientific uncertainties and room for different views, the ability to accomplish rapid "what if" simulations of different technical and data assumptions may help participants agree on planning objectives, on alternatives that might be formulated, and how different alternatives might affect their social and economic interests. A second means by which "what if" modeling can encourage agreement is to allow rapid assessment of tradeoffs by letting stakeholders experiment with different alternatives, immediately see the consequences, discuss tradeoffs, and search for mutual gains. In effect, collaborators collectively form (construct) their preferences for different alternatives as they evaluate alternatives.

Discussion Question: Is it essential that there only be one model ("single text") to focus the negotiation among stakeholders?

Stakeholder access to the technical models involves deciding whether model runs and output are only produced in common joint meetings or whether individual stakeholder groups are expected to use the model independently and outside organized group meetings. Experimental research suggests that different levels of model accessibility do not produce substantive improvements in stakeholder understanding of the system or more satisfactory negotiated outcomes (Zigurs et al. 1999). Questions of who operates the technical models must also be addressed. In some processes, the operation of the technical models may be delegated to an agreed upon individual or expert group. Requests for different model runs are provided to the model experts by stakeholder groups. Other processes may strive to increase model accessibility by allowing users to directly operate and run the technical model. In such cases, user friendly software interfaces are designed to allow decision-participants themselves to actively experiment and manipulate model inputs, assumptions, and parameters. The degree to which stakeholders may actively use the model can have implications for model design. For example, extremely complex and technical models may limit the degree of direct use nontechnical stakeholders may have with the model or whether technical models can be effectively used "on-line" during group negotiations (Roach and Tidwell 2007).

Discussion question: When and to what degree should stakeholders have access to the model?

Gaming exercises engage decision participants in real-time interaction in developing, experimenting, and evaluating alternatives. Because games are played in a group setting, the process may build social trust and personal relationships between competing and perhaps distrustful parties. Such games, however, require computer models capable of quick modification and real-time simulation. Models that require more data input or that have significant run time requirements need to solved outside the group process and the results brought back to the group. This model support process may allow more the use of more complex modeling structures, but limit the building of trust among the group members.

Discussion question: How can conversations among decision participants about the model and model outputs can be structured to increase likelihood of mutual learning and discovery of better alternatives?

Through the use of performance metrics, technical models can demonstrate cause and effect and reveal tradeoffs for decision participants. Such models can show improvements over status quo conditions. However, because CADRe models are designed and constructed to support collaborative negotiations, in most cases CADRe models are not designed to answer the question of what is best or most preferred alternative. Unlike, some analytical approaches (comprehensive benefit/cost analysis) that purport to measure or weigh the preferences or values decision participants place on all outcomes of alternatives, CADRe models themselves do not identify "optimal" or a single best solution. Rather CADRe processes rely on decision participants themselves to discuss, debate, and decide the relative importance and tradeoffs between alternatives. CADRe models are *decision aids* rather than *decision optimizations*. However, models might be designed to remove "inferior" alternatives. Inferior alternatives are those whereby a different alternative can increase performance on one or more metrics and not decrease the level of any other metrics.

Given the complexity of water resource management, technical simulations models will typically produce multiple outputs and complex combinations of performance indicators. Such models are also capable of processing thousands of "what if" scenarios. Yet model output must be conveyed to decision participants in ways that highlight trade-offs and facilitate comparison of alternatives. Furthermore, as new alternatives are developed by stakeholders, modelers will be confronted with new requests for new model output or modeled relationships. Selection of initial models and model construction should be sensitive to the need for model adaptation.

> *Discussion Questions: How can model design and use facilitate the search and sorting of potentially thousands of variations of alternatives that might be of interest to stakeholders without removing effective control of that evaluation from stakeholders? How can complex combinations of outcomes be presented in understandable ways to decision participants? To what extent should performance metrics be aggregated?*

IV. Bringing CADRe to Contemporary Water Policy: Some Challenges

There are barriers to as well as benefits from negotiation for dispute resolution. There have been numerous books and reports on barriers and benefits (RFF book) and the focus of this workshop paper is not on negotiation and collaboration per se. Instead this workshop asks a focused question, "how might computer models increase the likelihood of agreement among parties to a water management dispute?" Consequently, aim of this section is to discuss the challenges of this integration in contemporary water policy.

Within that focus, Section III discussed characteristics of a model development and utilization to increase the likelihood that computer simulations will help resolve conflict through negotiation. This section discusses some potential challenges that might be faced in bringing CADRe processes to existing water resource policy-making contexts.

Participation of Water Resource Management Agencies in CADRe

Agencies of governments have responsibilities to make decisions on specific issues within their authority. Often these agencies have constituencies that work with and support their responsibilities. On the other hand, CADRe processes include multiple stakeholders and other agencies and the process is designed to identify and possibly select a preferred alternative though a process of shared decision making. Several challenges to use of CADRe arise when there are multiple agencies in a CADRe process that are required to share decision making.

One challenge is that each agency will need to establish its role and participation in a CADRe process led by another agency. One agency may wish to take the lead in developing the collaborative model or coordinating the integration and negotiation process, however other agencies may not feel it appropriate that they participate in such a process. For example, a municipal water utility might want to initiate a CADRe process for securing a permit for a water supply reservoir, but the regulatory authorities who will need to judge the adequacy of the permit application by their own criteria may want to remain outside the CADRe process.

A second challenge is to establish the relationship to the decisions made in a CADRe process and the agencies own decision-making responsibilities. Agencies may be reluctant to sanction or participate in a CADRe because of a perception that they are ceding their delegated responsibilities for decision making to a process they cannot control. Conversely, agencies may sanction a CADRe process with an understanding that any decision collectively agreed upon by stakeholders will be supported subject to predefined conditions. For example, a FERC license applicant now has the option of the “alternative” and “integrated” licensing processes that follow the CADRe logic, rather than the conventional FERC licensing process (Swiger and Grant 2004). The alternative processes yield recommendations that the FERC commissioners can review, endorse and then implement, while still exercising the congressionally mandated mission contained in the FERC organic legislation.

> *Discussion Questions:*
>
> *Can decision making authorities who will need to judge the acceptability of a decision made in a CADRe process by their own criteria also be able to participate in a CADRe process that develops the essential aspects of the alternative they will have to judge?*
>
> *If the CADRe process is separate from the implementation authority, does a decision making authority need to affirm in advance that it will adhere to the results of CADRe, subject to the result meeting certain agency mission requirements?*
>
> *To what extent will the CADRe expectation of shared decision making be seen by some agencies as a diminution of their decision making authority or a compromise of their decision making responsibilities?*

A third challenge is to find the legal and organizational flexibility to engage in integrative bargaining. Today numerous separate agencies are asked to make decisions based on a bright line decision rule and are expected to use their own analytic procedures to evaluate how any water management alternative might mesh with that rule. These might be called agencies in the regulatory tradition, for example the EPA or agencies empowered to act under the Endangered Species Act. Other agencies have missions built on a resource management tradition where choices and tradeoffs are expected to be made and there are no hard and fast bright lines that constrain the choices that can be made. These include agencies such as the water development programs of the Corps and the Bureau of Reclamation and the FERC's regulatory and permitting program for hydro electric power generation (Hayes, 1998). All of these agencies responsibilities carry their own particular analytical, reporting and decision making rules, that follow from the original legislation governing the program and its subsequent interpretation by administrative rules and court rulings.

Agencies with regulatory responsibilities and bright line rules that have developed over time may be limited in their ability to participate in a CADRe process based on satisfaction of competing stakeholders values and interests and securing agreement as opposed to meeting requirements. Consider, strict adherence to the "avoid and minimize" regulatory language under the Corps and EPA fill permitting program under Section 404 of the Clean Water Act. Imagine a permit applicant has two reservoir options. The first option is expensive to construct, adversely impacts downstream fisheries, and results in 20 acres of wetland fill. A second, less costly option can enhance downstream fisheries through low flow augmentation, but results in 30 acres of wetland fills. Strict adherence to single objective of minimizing wetland losses could downplay the incorporation and consideration of fisheries impacts or preclude the possible acceptance of the second less costly alternative. This narrowing and constraint is compounded if multiple agencies are involved, and each has a single requirement to be met. In these cases agencies and their supporting constituency groups may enter into a negotiation with a necessarily predetermined position. The way they enter the negotiation might be described as follows: "Here is our fixed position based on authorizing law, our own analysis and constituency support, etc…now let's negotiate."

> *Discussion Questions: Are interpretations of agency missions and responsibilities too inflexible to accommodate a significantly expanded use of CADRe in water resources decision making?*

Agencies that must chose between and then fund projects from across a region or the nation may not find the results of the CADRe process useful, except in the single sense that agreements reached by those participating in the CADRe are evidence that there is limited controversy surrounding a plan or proposal. However, to reach agreement in the CADRe process may have required using performance metrics and perhaps making choices that were watershed and conflict specific. Because the measured outcomes predicted from the CADRe models are in terms of the place specific situation they will not be the same in all places. This means it is not possible to easily make comparisons across projects. This need for cross project comparison is what led to the requirement for tools such as benefit cost analysis and the representation of outcomes of different activities in comparable metrics such as dollars and habitat units.

> *Discussion Question: Are there cases where CADRe models must aggregate outcomes and stakeholder preferences either in dollars (benefit-cost analysis) or a system of subjective weights (multi-criteria analysis) into single quantitative rank alternatives?*

What are the possible ways to reconcile tensions between the performance needed to secure agreement in specific places and those needed for program administration and budgeting? How significant a problem is this for water management?

Developing CADRe Capacity

In the many CADRe applications analysts/modelers are also facilitators who have a mind set of expanding the gains from agreement to all parties, by framing and helping to analyze complex tradeoffs in terms agreeable to participants. Professionals with modeling and facilitation expertise are unique position to conduct successful CADRe processes, but the number of people with both skill sets is limited. In other situations, the analysts/modelers who contribute to the collaboration and the specialized facilitators who manage the process are different people. In either case for a successful collaboration efforts, analysts skills should include not only a technical modeling expertise, but skills that enhance productive engagement in collaborative processes, including ability to probe assumptions, keep many threads of argument in hand, and to communicate effectively. These are learned skills, often acquired and refined only by practice and experience. As professional training becomes increasingly specialized, there maybe a future challenge to train and expand the collection of professionals capable of conducting CADRe processes.

At the same time, agencies' staff are often unaware of CADRe processes or how CADRe processes work. Training and educational programs might be necessary to train and provide experience in leading CADRe processes.

Discussion Questions: Can these modeler/facilitator functions be separated? Are educational and training programs sufficient to train modelers and facilitators in the development, refinement and application of CADRe? What type of higher education training and education is necessary to train and expand personnel capable of implementing CADRe processes? Are CADRe practioners born (hired) or made (trained)?

Developing CADRe Acceptance

CADRe requires an upfront investment in time, money and personnel to develop collaborative models and discuss/negotiate alternatives. An often heard comment in discussions of the concept is that CADRe processes can shorten the time to reach a decision, but increase the time to develop the analytical models and output necessary to make a decision. There appears to be some support for that general observation. For example, in the late 1980s and 1990s, the Federal Energy Regulatory Commission faced an increasingly costly and time consuming process to relicensing nonfederal hydropower dams. The traditional licensing process relied heavily on the owner of the hydropower facility (the licensee) to develop the technical analysis for the relicense application and FERC staff to decide over contested conditions. Beginning with a series of reforms in the late 1990s, FERC began emphasizing joint study determination and more structured negotiations over license conditions between the licensee, resource agencies, and interested stakeholders. Such reforms have lengthened the time for the licensee to prepare a license application, but shorted the process of obtaining a license.

However, another possibility is that CADRe will increase the upfront costs *and* extend the time for a decision to be made. Unless there is some way to establish the primacy of the particular decision maker that will support the CADRe process and results (as in the case of the FERC processes) then the possibility that some entity will go outside the CADRe process and overturn its results means that CADRe may be viewed as nothing more than an added burden and source of delay. For example, water supply project permitting under the current 404 process can extend for decades. CADRe may be perceived as another opportunity to extend the process.

Such concerns may focus attention of stakeholders on the process of decision making rather than securing “better water management”. For example, a theme of CADRe is taking a system (watershed) approach to problem-solving. This system perspective is beneficial partly to identify more alternatives and increase the chance of identifying more mutually satisfactory alternatives. Yet, a regulated party may have reasonable fears that such an upfront and expansive examination of the issue may result in higher costs in order to secure the support of opposing stakeholders. For example, a municipality wishing to construct an off-stream water supply facility may also be asked to also improve downstream water quality, provide recreational facilities, and enhance fish populations, to secure agreement with their plan from others.

> *Discussion Question: How can the desire for decision making that reflects “a watershed approach ” or” integrated water resources management ” be supported if the cost of and time for the CADRe process is borne by a regulated party – with no end in sight?*

Scientific Expertise and CADRe Models

Water resource decision-making is often populated with people having specific and high level technical and scientific training. These people might be biologists, chemists, economists, or engineers within the agencies, regulated parties, and NGOs. Expectations and professional training may create false expectations for accuracy and rigor of technical models in CADRe processes.

Models can take many forms, but whatever the form, models all begin with a conceptual representation of the multiple relationships affecting one or more aspects of water management decision (a conceptual model) and then proceed to mechanistic and/or empirical equations (a mathematical model), followed by measurements and/or scientific judgment to empiricize the mathematical model so that it can be solved for prediction and/or explanation.

Models in CADRe build on existing scientific understanding, but necessarily simplify many relationships in order to be tractable and useful for policy and management decisions. Such models may not fully incorporate or reflect complex relationships and processes that are often the focus of one or more scientific disciplines. Within the modeling community, computer models designed to support collaborative negotiations for policy (management) decisions may not always (nor should) reflect state of the art modeling capabilities. Indeed, in certain settings, many CADRe models maybe, by design, highly simplified (low resolution) models intended to quickly link major system elements and demonstrate correct directional changes.

If technical and scientific participants to a CADRe process do not fully appreciate the different uses and roles of computer models for DRe, their criticism of the models may erode or undermine stakeholder confidence in using the models. Of particular note is that technical and scientific experts within agencies who possess specialized and professional training and education and have some decision making responsibilities. These technical staff may not always understand or appreciate the modeling needs of the collaborative process.

CADRe processes require that some decision-making authority be vested with the negotiating group. CADRe processes also require that knowledge and expertise be collected and reflected in shared computer models. However, agency staff may be reluctant to participate in such collaborative efforts because of a perception that stakeholders (often non-technical stakeholders) do not have the expertise to reach appropriate or "right" decisions. Indeed agency staff may perceive that disinterested scientific expertise produce better decisions than negotiations with self-interested stakeholder groups (Weible et al. 2004). Daniels and Walker sum up the challenge as follows:

> "[T]he juxtaposition between technical competence and open process is a defining characteristic of American policy formulation". .... Finding ways to increase the quality of technical expertise, while simultaneously increasing the inclusively the decision processes, is perhaps the fundamental challenge of effective policy formation." (Daniels and Walker, 19XX).

> *Discussion Questions: To what extent do scientific and technical experts accept the CADRe modeling process? How can agency and stakeholder experts be more productively engaged in CADRe processes?*

Justifying CADRe: The Public Interest Test

There will be criticism of defining CADRe success as reaching agreement among the stakeholders in the CADRE process. This success definition, some will argue, will not equate with making decisions in the "public interest". Whether negotiated solutions serve the public interest can be a complex debate, but we offer here two questions that will almost always be raised.

The first question is how representative the CADRe participants are of all possible stakeholders. CADRe participants must include all who the authority and ability (power) to go outside the CADRe process to get a different decision to serve their interests and values. However, inviting participants based on their "power" will raise concerns over equity (justice) of who was chosen. A higher level question is whether any selected group of stakeholders can be a substitute for democratic representation and decision making by the legislature, courts and agency with authority delegated to them (Crenson and Ginsberg 2002).

This being said, decision making costs (decision making delays and financial costs) increase with the number of included groups. Also there is a decreased likelihood of reaching agreement as group size increases. However, if an excluded group can influence the decision outcome outside of the process, then that group's exclusion may help achieve consensus on a preferred alternative, but the excluded group may be able to block implementation of the preferred alternative (for example by legal action). The public choice literature in economics, as well as the literature on environmental negotiation and alternative dispute resolution, includes numerous studies and recommendations about how this dilemma might be addressed through different forms of group decision rules, through the different roles that might be played by the convener of the negotiation (facilitation, mediation and arbitration), through the legislative actions to constrain the opportunities for opposition and through different rules for the distribution of project costs.

A CADRe analysis will illuminate the incremental opportunity costs of seeking different levels of performance metrics identified by the parties to the CADRe process. CADRe process participants may reach compensation agreements so that all decision participants deem themselves better off with the agreement that is made. For instance, a recreational fishing group may accept a series of recreational enhancements (boat landings, access points, etc) as compensation for enhanced load following flexibility that would alter downstream flow. In the FERC processes the costs of these actions fall on one of the decision participants who must agree to the license condition - the dam owner.

However, if the costs do not confront the CADRe participants who benefit from an agreement , the potential for cost shifting to others will make the outcomes acceptable for the parties to the negotiation but may come at a cost to the society at large. Therefore, a second question posed about whether agreement defines the public interest is “was that agreement secured by shifting costs to parties outside the process who were unrepresented in the CADRe discussion (for example, general taxpayers or utility rate payers as a group)?”

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Computer Aided Dispute Resolution (CADRe) Workshop

CADRe Case Studies Summaries

A Comparison of the CADRe Process: Perspectives from the Gila, Rio Grande and Willamette. Vincent Tidwell, Principle Member of the Technical Staff, Sandia National Laboratories

Use of Modeling to Facilitate Interstate Collaboration on the Lower Susquehanna River. Thomas W. Beauduy, Deputy Director, and Andrew D. Dehoff, Director of Planning and Operations, Susquehanna River Basin Commission

Role of Modeling in the Development of Interim Guidelines for the Operation of Lake Powell and Lake Mead. Carly Jerla, Hydraulic Engineer/Bureau of Reclamation – Lower Colorado Region

Climate Change and Water Planning in the Northwest: A New Application of Shared Vision Planning. Richard Palmer, Professor of Civil and Environmental Engineering

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Solving Urban Watershed Problems in Los Angeles through the Use of Collaborative Planning. Dan Rodrigo, Associate Partner, CDM

Changing the Rules for Regulating Lake Ontario Levels. Bill Werick, Werick Creative Solutions

Drought Preparedness in Northern California –People, Practices, Principles and Perceptions. Ane Deister, General Manager, El Dorado Irrigation District

A Comparison of the CADRe Process: Perspectives from the Gila, Rio Grande and Willamette

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Introduction

The value of collaboration, whereby various stakeholders work with policy-makers to address a particular issue has been well documented (Spash 2001; Claussen 2001; Susskind et al. 2001). These collaborative groups increasingly include model building as an effective way to inform the decision process. In fact, the use of models in open decision-making processes is not a new concept as there are case studies dating back to at least 1961 (Rouwette et al., 2002), while more recent examples include assessing the effects of sheep grazing on sage grouse populations (van den Belt, 2004), energy use in iron and steel production (Costanza and Ruth, 1998), air quality issues (Stave, 2002); sustainability of Arctic communities (Nicolson et al., 2002); park management (Videira et al., 2003); and water management (Moxey and White, 1998; Tidwell et al., 2004).

Although growing in popularity, the practice of Computer-Aided Dispute Resolution (CADRe) is still in its infancy and evolving rapidly. As a result, there is limited consensus on the exact meaning of CADRe, which is clearly seen by the different monikers by which it is known (e.g., mediated modeling (van den Belt 2004), cooperative modeling (Tidwell et al. 2004), shared vision planning (Palmer et al. 2007), computer-mediated collaborative decision making (Kreamer and King 1988). This proliferation is in part driven by the fact that each management and planning exercise is unique, requiring careful tailoring of the process.

In this paper we present three application of CADRe to water related planning problems, each with their unique demands. Our objective is to identify key forcings in the planning process and how they influence the structure of CADRe. In so doing we hope to demonstrate that while the details of each project differ considerably the general approach remains the same; that is, a process for involving stakeholders in the conceptualization, specification and synthesis of knowledge and experience into useable information (i.e., model) for the express purpose of addressing a complex problem. While not a comprehensive list, for the purposes of this paper we will focus our attention on three key forcings: the physical setting of the project, the available modeling toolset, and the decision landscape.

Background

In this paper we explore three CADRe projects that support water planning issues on the Upper Gila, Upper Rio Grande, and the Willamette. Below we provide a general description of the setting for each of these projects. In particular, we characterize each with respect to our three key forcings.

Gila: The Upper Gila and associated San Francisco Rivers in southwestern New Mexico provide the setting for our first case study. This region encompasses four large and sparsely populated counties, much of which is protected wilderness. Key water demands for this region include traditional flood irrigation and copper mining, which are being challenged by growing municipal demand and instream flow requirements to address endangered aquatic and riparian species. The driver for this project is the 2004 Arizona Water Settlements Act, which provides New Mexico an additional 140,000 acre feet of water from the Gila Basin in any ten year period. In addition, the State of New Mexico will receive $66-128M for paying costs of water utilization alternatives to meet water supply demands in the Southwest Water Planning Region of New Mexico. Implementation of these articles is the responsibility of the New Mexico Interstate Stream Commission (NMISC) in consultation with the Southwest Water Planning Group (SWPG). To help capitalize on this opportunity, a CADRe approach is being used to develop decision tools to support implementation of the articles of the 2004 Arizona Water Settlements Act. Application is occurring early in the planning process in a basin where no water resource management or planning models exist.

Rio Grande: Our second case study also focuses on New Mexico; specifically, the Upper Rio Grande which we define as the river reach from the Colorado border to Elephant Butte Reservoir in south central New Mexico. Along this reach the Rio Grande drains the Sangre de Christo and Jemez Mountains along with extensive high desert regions. River water is heavily used for traditional flood irrigation throughout the basin while Albuquerque, Santa Fe, and other small communities pump municipal water from groundwater aquifers that are in direct communication with the river. Beyond the uses by irrigators and growing municipalities are riparian evapotranspiration, instream flows to support the endangered silvery minnow, and evaporative losses. Currently there is no immediate water planning driver for this project; however, future needs to support water rights adjudication and changing instream flow requirements are pending. Toward this need, a CADRe approach is being implemented to develop decision tools to assist with stakeholder engagement and rapid screening analysis to support future planning projects. These exercises are being conducted in a basin where numerous trusted water management tools exist.

Willamette: Our third case study involves the Willamette River in western Oregon. The Willamette is the 13th largest river in the continental United States in terms of stream flow and produces more runoff per unit of land area than any other river. The U.S. Army Corps of Engineers (USACE) operates 11 major water storage reservoirs on tributaries to the Willamette River to provide irrigation water, inexpensive power, and flood control. Water managers on the Willamette face a number of difficult and closely interrelated challenges associated with the Endangered Species Act, Clean Water Act, and growing demands and stresses on the resource. Considerable public planning has already been accomplished in the basin with much of the assessment and planning phases for solving some of the basin's problems codified in evolving regulations. CADRe has been implemented to facilitate discussions on water resource management in the basin, with decision tools built to link multiple factors such as water quality (including temperature), aquatic and terrestrial biological communities, and other concerns at different locations throughout the basin. Again, this basin benefits from the availability of several detailed and trusted water resource management models; however, these tools are not currently coupled.

Methods
As the characteristics for each of our case studies differ in terms of their physical setting, availability of water management models, and the decision landscape, so too do the details of the CADRe application. Here we compare and contrast stakeholder involvement in the development and application of decision tools as experienced in each case study. Please note that in each case these projects are on-going and thus are continuing to evolve.

Gila: In the Gila Basin the New NMISC in cooperation with the SWPG, the U.S. Bureau of Reclamation (USBoR)(lead federal agency), U.S. Fish and Wildlife (responsible for Endanger Species Act compliance) and the Governor's Office established a science, planning, and public outreach program aimed at addressing opportunities associated with the Arizona Water Settlements Act. In this case, the CADRe exercise represents one key facet of a broader planning program. The objective of this effort is to develop a decision support tool that has broad acceptance across the science, decision-maker and stakeholder community.

In an effort to establish an open and transparent modeling process a "cooperative modeling team" was created. The team consists of representatives from each of the planning agencies noted above plus municipalities, irrigated agriculture, ranching and the environment. In addition, a professional facilitator and meeting note taker have been responsible for managing the flow of each meeting. This team has been meeting on a bi-monthly basis since it was formed in September of 2005. Because of the wide geographic dispersion of the team members meetings are held via web/voice conferencing. In addition, quarterly face to face meetings coinciding with the monthly SWPG meetings are held to help build a sense of team among the members while giving the general public an opportunity to stay informed and provide feedback.

Because of the lack of other planning tools in the Gila, the CADRe process has been responsible for building decision tools from the ground up. In this way the cooperative modeling team has assisted with system conceptualization, data gathering, defining causal relations and quantifying key physical processes. Actual coding of the model has been performed outside the meetings by the authors of this paper. The resulting model is developed in a system dynamics framework to addresses the principle water supply and water demand sectors within Southwestern New Mexico; specifically, surface water, groundwater, land surface processes, institutional controls, environmental, water use, and future water utilization options. Model simulations are conducted on a daily time step over a variable planning horizon. Spatially, the model is disaggregated according to eight river reaches as defined by active gauging stations.

Rio Grande: The CADRe process as applied to the Upper Rio Grande has a very different character than the Gila. Much of the difference is due to the fact that the CADRe effort is not focused on an immediate planning issue; rather, the effort is supporting tool development for future exercises. While there are other trusted water planning models for this basin, the purpose of the CADRe effort is to develop decision support tools for rapid scenario screening and to provide a vehicle for stakeholder engagement in future water planning. In this way the model sacrifices some spatial and temporal resolution for rapid simulation and coupled process.

Again, a cooperative modeling team was formed; however, it is populated only by technical representatives from state and federal water agencies; specifically, the technical team for the Upper Rio Grande Water Operations Model (URGWOM), which consists of scientists and modelers from the United States Geological Survey, the USACE, the USBoR, and the NMISC. Collaboration has occurred primarily through monthly to bi-monthly meetings over the last year. Initial meetings were dedicated to familiarizing the cooperative modeling team with Powersim Studio 2005, the commercially available software package used to build the CADRe model. Subsequent meetings focused on demonstrating the specific framework, assumptions, and methods used to build the decision support model. During this second phase, the model was changed, added to, and improved upon significantly, based on the knowledge of the cooperative modeling team. Finally, once requested changes and enhancements were complete, the members of the technical team reviewed the model individually prior to an external model review.

The resulting model focuses on the Rio Grande surface water and groundwater system in northern and central New Mexico. This river basin scale model integrates three existing MODFLOW groundwater models (at reduced spatial resolution) and one RIVERWARE surface water model (at reduced temporal resolution) in a system dynamics framework. To this physical model, a simple human behavioral model and user interface was added. The resulting tool runs 40-year simulations on a laptop computer in tens of seconds, with inputs that are easily changed by non-expert users via a graphic, user-friendly interface.

Willamette: The Willamette provides yet another variant on the CADRe process. The key driver in this case study is a recently issued biological opinion and associated regulatory Total Maximum Daily Load (TMDL) for water temperature. These new regulations require the USACE to undertake significant actions with regards to their current reservoir operations. Local municipalities and pulp/paper industries that discharge waste water to the river are also subject to these new regulations. In an effort to help meet the TMDL faster and to reduce the cost and conflict of compliance with multiple regulations while delivering broader environmental benefits, a coalition of stakeholders formed the Willamette Partnership (WP). The WP recently received a grant from the Environmental Protection Agency to develop an ecosystem marketplace where water quality and conservation credits can be traded.

The USACE in cooperation with the WP (and the broad stakeholder group that they represent) are spearheading the planning process. CADRe has been implemented to assist with the development of decision support tools for the evaluation of alternative reservoir operations and conservation credit systems that might be used to meet the new TMDL. Specifically, these tools need to couple river/reservoir routing with temperature dynamics (which does not currently exist). In this case, the stakeholders represented by the WP requested not to be directly involved in the model development phase; rather, their desire was to assemble a group of local experts who are more familiar with or who have experience in modeling temperature dynamics on the Willamette. This team serves an advisory role to guide and help the core modeling team (authors of this paper) during the model development process, as well as to review the finished models to ensure that they meet the intended goals of the project in a scientifically defensible manner. This review process will build a level of confidence with the stakeholders that the models can be trusted for their intended use. Meetings with this advisory team occur quarterly, given the demands of the project and the physical separation of the advisory and core modeling team.

The resulting model is once again developed in a system dynamics framework. Because of the importance of temperature dynamics, the model operates on a 6 hour timestep. The model disaggregates each tributary and the mainstem into multiple interacting reaches and addresses each reservoir individually (with associated operations rules). The model tracks river discharge and temperature as a function of changing reservoir operations, climate conditions, and loads to the river. Also considered are economic costs, recreational values and power generation. Model outputs are ultimately assessed in terms of TMDL compliance. Throughout this process considerable effort has been made to demonstrate the degree to which this lower resolution systems model compares to results of the higher fidelity (yet uncoupled) HEC ResSim and CE-QUAL-W2 models.

Discussion

Information contained in this short paper is intended to provide necessary background on these three case studies and the overarching process framework relating the three CADRe exercises. The presentation and forthcoming paper will provide further analysis on the relation between problem forcings and the CADRe process.

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Use of Modeling to Facilitate Interstate Collaboration On the Lower Susquehanna River

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In 2002, the Susquehanna River Basin Commission (the Commission) convened the Conowingo Pond Workgroup (the Workgroup) to recommend a management plan for the Conowingo pond, a 14 mile-long interstate water body created by construction of the Conowingo dam on the Lower Susquehanna River. The pond, which straddles the Pennsylvania-Maryland border, serves multiple uses. During recent low flow conditions on the Susquehanna River, the pond demonstrated an inability to meet all existing uses, and the Commission had determined that a more comprehensive management scheme was needed to avoid conflicts. As a regional, interstate agency with basinwide water allocation and consumptive use regulatory authority, the Commission was uniquely qualified to initiate and lead the Workgroup effort.

The Workgroup undertook a four-year planning effort to evaluate operational alternatives for the pond and to recommend to the Commission a management plan that best meets the water use needs identified by the Workgroup. Additionally, the Workgroup was tasked with identifying management actions that the Commission should incorporate into its regulatory and water resource management programs. The Workgroup completed their report in March 2006, which served as the basis for the Conowingo Pond Management Plan adopted by the Commission.

The composition of the Workgroup was intended to represent the interests of key stakeholders in the operation and use of the pond. The membership was comprised of representatives from federal and state agencies, local jurisdictions, operators of the lower Susquehanna hydroelectric facilities and Peach Bottom Atomic Power Station, local water utilities, and the Commission. The Workgroup met several times a year and provided direction, oversight, input, and review for the planning effort and its results.

As noted above, the Conowingo pond was created by the construction of the Conowingo dam in 1928 to provide hydroelectric power generation for the Conowingo Hydroelectric Station. Operation of the dam by Exelon Generation, Inc. (Exelon) is subject to the requirements of the Federal Energy Regulatory Commission (FERC). These requirements include provisions related to minimum flow releases and maintenance of recreational pond levels. Current minimum flows, which vary by season, were established to provide protection for fishery resources, with highest minimum flows required during the anadromous fish migratory period in spring, and intermittent flows permitted only during the winter, when fish populations are limited. The minimum flows resulted from a multi-party settlement reached in 1988 after a prolonged, contentious legal battle during the last FERC relicensing of Conowingo dam.

By virtue of the pond, a stable source of water storage for other purposes was also provided. The Muddy Run Pumped Storage Hydroelectric Facility, built in 1968, cycles water back and forth from the pond for additional power generation. The water in the Conowingo pond is also used for public water supply by the City of Baltimore and Chester Water Authority, and for industrial cooling by the Peach Bottom Atomic Power Station. Finally, the pond provides a valuable recreational, fish, and wildlife resource.

Under normal and slightly below average flow conditions, there is generally ample water in the lower Susquehanna River to maintain hydroelectric operations; support water supply demands; sustain recreational, fish, and wildlife activities; and meet required flows to downstream river reaches and the upper Chesapeake Bay. However, during more severe low flow conditions, the available water becomes insufficient to meet all prescribed uses and required needs. During such periods, as Exelon operates the Conowingo dam in accordance with its FERC license requirements, storage levels in the Conowingo and Muddy Run facilities begin to decline. Declining pond levels pose a threat to Peach Bottom's cooling water intake, Muddy Run's intake, the use of recreation facilities, shore habitat, and maintenance of downstream flows. In response to declining pond levels and worsening conditions, FERC has authorized Exelon on five occasions to temporarily include water leaking through closed wicket gates toward meeting the dam's daily minimum flow release requirement. The 1988 settlement agreement specifically excludes that water from the minimum release calculation, but FERC has overridden the exclusion during the four events.

The first year of Workgroup deliberations was spent sharing information and developing working relationships among stakeholders with different – and often conflicting – objectives. In order to investigate and recommend a management plan for the Conowingo pond, it was important that the members of the Workgroup provide insights to the diversified interests related to the pond's resources. These interests include hydroelectric power generation, public water supply, water use upstream of the Conowingo pond, minimum flow release requirements, minimum dissolved oxygen requirements, summertime minimum recreational pond levels, multipurpose benefits, anadromous fish migration, upstream reservoir storage, environmental resources, and cooperative management. The Workgroup collectively assessed the interests and identified problems and conflicts that needed to be addressed. They were:

1. Maintaining FERC mandated minimum flow releases from the Conowingo pond can lead to disruption in power production, water supply withdrawal limitations and diminished recreational opportunities during significant low flow events, and depletes storage that might otherwise be available for release during low flow events of extended duration.

2. Temporary waivers to allow inclusion of gate leakage towards meeting minimum flow releases have been authorized by FERC four times (1999, 2001, 2002, and 2005) during recent droughts, but only under emergency or near-emergency conditions when time is critical and serious impacts are developing with no projected improvement.

3. Increased salinity levels in the Susquehanna River downstream of the Conowingo dam during low flow conditions can negatively impact the water supply for the city of Havre de Grace, Maryland, located at the mouth of the river.

4. Consumptive water use in the Susquehanna River Basin, from and upstream of the Conowingo pond, is increasing and could eventually impact negatively on the pond and those who rely on its water.

5. Commission-owned water supply storage at two federal reservoirs in the upper basin is managed under operating rules that were developed for water supply users elsewhere in the Susquehanna River Basin. Releases from these reservoirs are not mandated by FERC license requirements and may not provide optimum and timely benefits to the Conowingo pond during low flow conditions.

6. Increasing public water supply needs for Baltimore City, Harford County, Chester Water Authority, and the areas of Pennsylvania and Maryland surrounding the Conowingo pond are expected to lead to requests for greater withdrawals from the pond or the Susquehanna River just upstream.

7. Increased consumptive water use needs (i.e., cooling water for a new thermoelectric power plant) could require additional withdrawals from the pond.

A valuable tool developed and used during the planning study was the Commission's OASIS computer model. This daily flow model incorporated more than 70 years of hydrologic record throughout the basin and was used to measure the impacts of various operation parameters on the pond and flow conditions downstream. In addition to hydrologic flow records, the model included representations of the operation of large public water supply withdrawals, power plants, and reservoirs in the Susquehanna River Basin, and incorporated basinwide estimates of existing and future consumptive water uses. Comparative output displays of Conowingo pond levels and dam releases allowed the Workgroup to evaluate numerous operation alternatives and make recommendations for the management of the pond. Because the stakeholders were involved in development of the model, there was good confidence that it accurately reflected current operating conditions.

Using the hydrologic model, baseline conditions (i.e., existing operations) were established and a series of 32 initial alternatives was evaluated. Key parameters identified for the evaluation included minimum downstream flow requirements, credit for leakage of water at the dam, water supply withdrawals under normal and low flow conditions, consumptive water use in the basin above the Conowingo pond, and the use of Commission-owned storage at two upstream reservoirs to augment low flows. The workgroup participated in computer-aided negotiations (CAN) used to perform efficient evaluations of the long-term implications of changes in operating policies and facility configurations. The iterative process embodied in the CAN sessions served to inform the Workgroup members about the pros and cons of many alternatives on a consistent and balanced basis. Over time, the CAN sessions were also valuable in building the credibility of the model with Workgroup members.

After review of the initial 32 alternatives, the Workgroup developed 6 final alternatives for closer analysis leading up to the selection of a preferred operating plan. The alternatives differed mainly in operating rules for release requirements from the Conowingo dam during times of low flow. Parameters such as demand for water supply, water withdrawal operations, and upstream consumptive use were kept constant to allow for direct comparison between alternatives. A thorough evaluation of the six preferred alternatives using the OASIS model led to the selected plan, which contains favorable elements of several of the final alternatives.

Based on results of the modeled alternatives, the Workgroup identified the leakage and the minimum release requirement as the most critical parameters in managing low flows and enabling the Conowingo pond to remain viable during droughts. While water conservation measures and the release of augmenting flow from upstream reservoir storage were deemed reasonable measures worthy of consideration, the supplemental volume of water they provide was found to be small relative to the daily fluctuations of the pond, and simply did not offer substantial drought mitigation. Therefore, the selected Conowingo Pond Management Plan was based on establishing a formal protocol to implement a credit for leakage, and to specifying the hydrologic conditions under which the credit is warranted.

The selected plan includes initiation of an automatic credit for leakage of up to 800 cubic feet per second (cfs), when the flow conditions at the upstream Marietta gage decline to a flow of 1,000 cfs greater than the seasonal flow thresholds ("Q-FERC") established by FERC for that gage. The Marietta flow threshold is 5,000 cfs between June 1 and September 14, and decreases to 3,500 cfs on September 15 through the end of November.

Modeled simulation runs of operating the resource under the recommended guideline produced favorable results. They demonstrated the most favorable balance for preserving adequate levels in the pond, ensuring reliable multipurpose use of the pond, and meeting the requirements for the quantity of water released to the downstream reaches of the Susquehanna River and the Chesapeake Bay. To further avoid potential negative impacts, the Workgroup conditioned its recommendation with restrictions that prohibit Exelon from automatically taking a credit for leakage during the spring fish spawning and migration season (April 1 – June 30) and limit the credit to only the portion of the 800 cfs that is absolutely necessary to maintain viable pond levels.

Implementation of the selected plan will require that Exelon successfully petition FERC for an amendment to the existing license to include the altered disposition of the gate leakage during drought conditions. The thorough planning effort of the Workgroup over the past four years and formal support of the proposed license amendment by the agencies involved are expected to be positive input to the FERC review process. The Workgroup will convene annually to review project operations, assess the potential for hydrologic conditions to develop into drought, and conduct a drought operations exercise. The hydrologic model used to develop the management plan is to be kept up to date by the Commission for the Workgroup's use, and will accurately reflect current water withdrawals in both the pond and the Susquehanna River Basin, as well as current policies and operation protocols. The Workgroup will also be responsible for reviewing and updating, as necessary, the selected management plan on a periodic basis not to exceed five years.

The planning study also identified three related actions beneficial to managing the Conowingo pond that the Commission supports including in its regulatory and water resource management programs. They are:

1. Consideration of the impacts of increasing consumptive water use in the basin on the Conowingo pond and determination of what measures, if any, are necessary to mitigate the impacts.

2. Investigation of the water supply storage owned by the Commission at the federal Cowanesque and Curwensville Lakes projects for alternative operational strategies to provide more effective low flow augmentation, including benefits to the Conowingo pond and instream resources below the dam.

3. Incorporation of key management principles and tools described in this report, including the use of the annually updated hydrologic model, into the Commission's regulatory and water resource management programs.

The Commission demonstrated its support for implementing the above recommendations by formally adopting the Conowingo Pond Management Plan in March, 2006.

The Workgroup's report, with its documented and thorough analysis, provides valuable information for the Commission, public water suppliers, power companies, and environmental resource agencies in making regulatory and management decisions involving the resources of the lower Susquehanna River. The Commission's OASIS model developed during the Workgroup's deliberations will continue to serve this same community in the years ahead.

Given the potential for increased water use and future withdrawals in the upstream basin and from the Conowingo pond, the adoption of the Conowingo Pond Management Plan and related actions is intended to ensure sustainable operations and a reliable water source for all needs, from public water supply and power generation to recreation and aquatic habitat, for many years to come.

Role of Modeling in the Development of Interim Guidelines for the Operation of Lake Powell and Lake Mead

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INTRODUCTION

The Bureau of Reclamation (Reclamation) is the agency designated to act on behalf of the Secretary of the United States Department of the Interior (Secretary) with respect to the operation of Lake Powell (Glen Canyon Dam) and Lake Mead (Hoover Dam) on the Colorado River. Lake Powell and Lake Mead have a combined capacity of over 50 million acre-feet (maf), and when combined with the other 10 mainstem reservoirs, the overall storage capacity is four times the average natural flow of the Colorado River (15 maf over the past 100 years). The Colorado River system provides water to approximately 30 million people and is used to irrigate approximately 3 million acres.

Reclamation is faced with the problem of limited water supplies and increasing demand in the fastest growing region in the country. The major challenge is to meet the demands of a diverse group of stakeholders comprised of state agencies, Native American tribes, irrigation districts, municipalities and other non-governmental organizations with often conflicting interests such as municipal, industrial, and agricultural supply, hydropower production, recreation, endangered species and other environmental concerns. These issues are intensified by the extreme hydrologic variability that is characteristic of the Colorado River. During the period of 2000 through 2007, the Colorado River Basin experienced the worst drought conditions in approximately one hundred years of recorded history. Currently, the Department of the Interior does not have specific operational guidelines in place to define the circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead nor to address the coordinated operations of Lake Powell and Lake Mead, particularly during drought and low reservoir conditions.

Controversy has been synonymous with the Colorado River since the signing of the Colorado River Compact in 1922, negotiated during a period of relatively high flows. Accompanying the drought beginning in 2000 was increased tension among the Lower Division states (Arizona, California and Nevada), the Upper Division states (Colorado, New Mexico, Utah and Wyoming), and other stakeholders including recreational and power interests as the levels of Lake Powell and Lake Mead dropped. In May of 2005, Secretary Norton directed Reclamation to engage in a process to develop additional operational guidelines for Lower Basin shortages and the operation of Lakes Powell and Mead under low reservoir conditions.

In the fall of 2005 Reclamation announced the intent to initiate a National Environmental Policy Act (NEPA) review process. This process is near completion with the publishing of the Final Environmental Impact Statement (EIS) for Colorado River Interim Guidelines for Lower Basin

Shortages and Coordinated Operations for Lake Powell and Lake Mead on target for the end of September and the Record of Decision anticipated to be issued in December. Computer modeling has played a central role in developing and analyzing the EIS alternatives as well as selecting the Preferred Alternative.

Reclamation uses modeling extensively for planning purposes to represent the complex system of reservoir operations in the Colorado River basin. Reclamation's official hydrologic planning model, the Colorado River Simulation System (CRSS), is a necessary component of long-term planning and policy studies. The exploration of alternative reservoir operating polices and the assessment and review of existing policies using modeling is essential to ensure that operations can respond to the changing hydrologic conditions and management objectives on the river.

MODELING

In addition to performing planning studies to inform decision-makers, a model facilitates communication and understanding of the policies between stakeholders and water managers. A variety of modeling systems are available to water management agencies and stakeholders although often they do not offer the flexibility required to mimic the changing multiple objectives of water projects and require significant effort and expense to maintain and update (Zagona et al., 2001).

RiverWare

Reclamation utilizes RiverWare™ that overcomes these shortcomings by its flexible policy expression and the extensive library of physical processes algorithms (Zagona et al., 2001). RiverWare™ is a computer software package developed by the University of Colorado Center for Advanced Decision Support for Water and Environmental Systems (CU-CADSWES). RiverWare™ was developed with the intention of meeting the needs of water management agencies in replacing obsolete site-specific models. It is a generalized river basin modeling tool than can be applied to a river basin of interest for operations and planning purposes (Zagona et al., 2001). RiverWare™ is visually oriented and displays and represents the physical river system using a series of predefined objects such as reservoirs, river reaches, canals, etc. These objects are linked together and information is propagated between them via the links when a simulation is performed.

Official River Operations Model CRSS

CRSS is Reclamation's designated monthly timestep model used to simulate reservoir and river operations in the Colorado River Basin. It was originally developed in the 1970's and 80's as a FORTRAN program. In the mid-1990's, Reclamation re-implemented CRSS in RiverWare, with involvement of interested stakeholders. The *Law of the River* and other operating criteria are expressed as logical rules in RiverWare's rule language that can be understood and modified to meet changing objectives in the basin and are isolated from the physical process model. The RiverWare Policy Language (RPL), viewed and modified outside of compiled code, allows the specification of logical "if-then-else" or "while" statements, and other customized functions to represent policy. The ability of this language to capture significant detail is demonstrated by its ability to capture the complexity of the operational policies in CRSS. The policy ruleset drives the simulation by setting values on variables within objects on the workspace. The objects then solve their hydrologic equations according to the values the stored values.

The RiverWare™ version of CRSS is now the officially accepted version of the model. The process of implementing CRSS in RiverWare™ clarified many policies not documented in the FORTRAN version and was crucial in providing the foundation upon which new policies can be added. The flexibility of RiverWare™ has made possible model studies for long-term planning, mid-term forecasting and short-term scheduling and Reclamation now has a variety of RiverWare-based models in use throughout its Regional and Area offices in the Colorado River Basin.

Long-Term Planning Studies

Long-term planning studies examine the effects of changes on the river system – new or modified structures, change in hydrology or climate, changes in water use and demands, and changes in operating procedures. Since the enactment of NEPA in 1969, proposed major federal actions that may significantly affect the quality of the human environment must undergo analysis to assess the potential environmental impacts associated with the proposed action and those effects are disclosed prior to implementation. These studies pursuant to NEPA necessitate long-term planning model runs that compare several operating policy alternatives and their potential impacts. At the initiation of a NEPA process, public scoping is conducted to solicit input from the public and inform the identification of key issues and potential alternatives to be addressed in the study. The selected alternatives are modeled in CRSS to assess potential impacts to the various resources. Examples of completed long-term planning studies include the Interim Surplus Criteria EIS and the Lower Colorado Multi-Species Conservation Plan (Fulp and Harkins, 2001).

Due to the potential wide-ranging effects of these impacts, the time-horizon over which the model is run is on the order of decades. Different operating policies are implemented in separate rulesets, which are interpreted by RiverWare™ when the model is run. Model output is managed and presented using Riverware's Graphical Policy Analysis Tool (GPAT) jointly developed by CU-CADSWES and Reclamation. GPAT presents the output from several RiverWare simulations in graphical comparative figures allowing the impacts of policy alternatives to be fully explored (Wheeler et al., 2002).

STAKEHOLDER INVOLVEMENT

Colorado River stakeholders were directly and substantially involved in the development of the EIS alternatives. These major stakeholder groups are Cooperating Agencies (Bureau of Indian Affairs, US Fish and Wildlife Service, National Park Service (NPS), Western Area Power Administration (Western) and the United States Section of the International Boundary and Water Commission), the seven Basin States, Indian Tribes and a consortium of environmental non-governmental organizations (NGOs).

Anticipating this high stakeholder involvement, Reclamation developed, in collaboration with CU-CADSWES, a RiverWare™ model referred to as CRSS-Lite (Lite). Lite was designed to provide a faster, less complex alternative to CRSS for the purpose of screening policy alternatives, policy evaluation and comparing the results of different operations in the Lower Basin and at Lake Powell (Jerla, 2005). A group of stakeholders established the initial user-requirements and were kept actively engaged in the development process. Reclamation worked individually with the Cooperating Agencies, Basin States and NGOs over the course of two years providing technical assistance. Lite was the principal modeling tool and during this time some 200 different operating scenarios were modeled and analyzed. Lite and CRSS are highly credible tools in the stakeholder community for modeling Colorado River Basin study efforts.

In July 2005 and then updated in July 2006, the NGOs submitted their "Conservation Before Shortage" proposal. In February 2006 (and reaffirmed in April 2007) the Basin States submitted a "Preliminary Proposal Regarding Colorado River Operations" in a letter to the Secretary. Through this proposal the Basin States' reached a consensus for the first time in history on issues of this magnitude. Additionally, a third operational strategy was modeled and developed in coordination with the NPS and Western. All three strategies were included among the alternatives analyzed in the EIS.

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Climate Change and Water Planning in the Pacific Northwest: A New Application of Shared Vision Planning

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Introduction

There is general consensus in the scientific community that global climate is changing (IPCC 2007). The precise impact of climate change on water resources and the urban environment is less certain. Although paradigms exist that outline approaches to evaluate the potential impacts of climate change on water resource systems (Gleick 1999), no single approach has been generally accepted and the uncertainties associated with the application of any approach are large. The greatest source of uncertainty associated with climate change impacts arises from the range of future scenarios utilized by GCMs. Applying an evolving science to real decisions concerning water resources thus requires gaining the support and trust of those responsible for decision making. However, since climate is, in fact changing, evaluating its impacts is important when investigating the future viability of water resource systems.

This paper investigates the use of a "shared vision planning" approach in a regional water study with the goal of institutionalizing the incorporation of climate impacts into forecasts of water supply and water demand. This is accomplished by the creation of a technical advising committee that strived to identify the potential impacts of climate change in their region through a consensus process and then incorporated these impacts into a series of water system simulation that estimated the likely impacts. This paper begins by defining the conflict that was to be resolved by the shared vision planning approach. It then describes the institutional approach that was taken in response to this perceived conflict. Next, the paper describes a consensus process in which a group of engaged stakeholders devoted six months to defining likely impacts to the region. The paper concludes with a discussion of the challenges of this approach and the lessons learned.

The Conflict to be Resolved and the Institutional Setting

As few as five years ago, some still suggested that global climate change was not a significant problem, that the extreme events that were occurring were part of the natural variability of climate, and that man's activity had little or nothing to do with climate or climate change. Given these perspectives, it is not surprising that water planning agencies in many areas of the country faced significant resistance when they sought to incorporate the potential impacts of climate change into their long range planning. This inability to acknowledge that climate change was occurring and that it was having significant impacts made it difficult to implement action at a local level. The Fourth IPCC Assessment Report has essentially removed any doubt about the need to address climate change. Fortunately, prior to the publication of that report many parts of the US were already attempting to address climate change.

The Puget Sound Region (the Puget Sound Region here is defined as that portion of Washington State that is in the three county region of King, Snohomish, and Pierce County, and other nearby areas) has been a leader in environmental awareness. Water resource planning performed in this area, whether performed by a federal agency like the Corps of Engineers or by a utility, like Tacoma Public Utilities, has long been performed in a "fish-bowl" atmosphere in which planners have been expected to engage resource agencies, Indian nations, regulators, stakeholders and others in an inclusive planning process. Several of the most visible local elected officials (including the Mayor of Seattle and the King County Executive, to name just two) have been recognized nationally as leaders in advocating the need to address issues associated with climate change.

Despite the "fish bowl" environment, or perhaps partially because of it, points of conflict have developed between resource agencies, water providers, and wastewater providers in the region. Two major points of conflict revolve around water supply sources in the region and long-term water demands. For over 30 years, Seattle Public Utilities, Tacoma Water, and the Corps of Engineers sought to interconnect the Seattle and Tacoma water supply systems. This was seen as an excellent alternative in addressing long-term water needs in the region. This interconnection appeared to be imminent, until an existing hydropower project in the region became available as a potential public water supply source, and purveyors sought to include this source in the intertie. An agreement could not be reached on whether to include this source, leading to a number of the purveyors that had been served by Seattle to seek to develop the hydropower power project on their own. The purveyors, when renewing their existing contract, signed a long-term agreement to decrease the amount of water they received from Seattle, and instead develop this new supply source and obtain water from Tacoma in the interim. In addition, King County, sought to expand its recycling efforts to include waste water reuse, which would make available more water regionally for special purposes. The potential impacts of climate change have played into this regional debate, as climate change might place more strain on the region's water resources. In addition, utility water demands projections in the past have over estimated water demands, adding uncertainty to the need to provide more water for the region. In addition, no forecasts have adequately addressed climate change impacts.

In the Winter of 2005, King County initiated a planning process designed to improve the quality and access to information used in planning for regional water resources and regional water demands. The County was quickly joined by a number of other entities, including the Muckleshoot Indian Tribe, Washington Department of Ecology, Washington Department of Fish and Wildlife, Washington Department of Health, King County Department of Public Health, Seattle Department of Public Health, Pierce County, City of Auburn, Suburban Cities Association, Cascade Water Alliance, Cedar River Water and Sewer District, Lakehaven Utility District, Seattle Public Utilities, Tacoma Public Utilities, Woodinville Water District, Shared Strategy for Puget Sound, Center for Environmental Law & Policy, and Washington Environmental Council. The planning framework that is in place:

> "*outlines a multi-year schedule for studying water resource conditions and management approaches related to meeting the combined needs of water for people and fish from all available sources, including reclaimed water and conservation. In addition, the planning process is exploring the potential impact of climate change on water planning, as well as small water system issues and problems. Efforts of this planning process will produce analyses, information and potential projects which may be used in future water planning activities………this planning process is expected to produce information and*

recommendations in seven topic areas: water demand forecast, water supply assessment, climate change impacts, reclaimed water, tributary stream flows, source exchange strategies, and small water systems." (http://www.govlink.org/regional-water-planning/index.htm)

In this process, a number of technical committees were established to provide information on pressing issues. One of these is the Climate Change Technical Committee. It has approximately 25 members. Its goal is to "assess climate change impacts on water demand, water supplies and instream flows."

Climate Change Technical Committee

The initial tasks in evaluating the potential impacts of climate change on water resources in the Puget Sound Region faced by the Technical Committee was to: 1) develop an acceptable process for organizing and managing the committee, 2) create a common vocabulary and a shared understanding of climate change and its impacts, both on a global and regional scale, and 3) define research tasks that are necessary to quantify the potential impacts of climate change in the region. These goals include the interpretation of existing models and the development of models that are to be incorporated into the decision making process. Throughout the process, efforts were made to seek consensus within the committee, even when this required lengthy debates, review of the published literature, and presentations from experts.

Organization and Management

The committee proved to be "self-selecting" in that all individuals involved in the regional planning process that desired to be on the committee were welcomed. Approximately 25 people, representing some 18 different organizations, now compose the core group. A professional facilitator was used to manage meetings. Researchers from the Department of Civil and Environmental Engineering and from the Climate Impacts Group of the University of Washington provided technical support in creating technical material for individual meetings and for committee reports. King County Department of National Resources and Parks provided the institutional technical lead for the committee. The committee first met in March of 2006 and ground rules for committee procedures were in place by April of 2006.

Common Vocabulary and Shared Understanding

To help create a common vocabulary within the committee and to generate a shared understanding of the potential impacts of climate change, the committee embarked on a joint effort to create a set of "Climate Change Building Blocks." The group concluded that such an effort would result in a document that could be used to crystallize the group's understanding of climate change, to provide information for interested stakeholders outside the committee, and to ensure the engagement of all of the members. The goal of the document was to summarize the major impacts that were likely to occur due to climate change in the Puget Sound region in a clear and concise manner that could be easily understood by engaged stakeholders and was based on peer-reviewed literature.

An initial draft of the Climate Change Building Blocks was created by the researchers in April of 2006. This document relied on the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change, reports produced by the Climate Impacts Group and peer reviewed publications on climate change. This draft was augmented, modified, edited and discussed for a seven month period. The document was the focal point of monthly committee meetings during this period. By the October meeting, a consensus was reached on the language of each of the thirteen Building Blocks (Table 1). The final document contains extensive documentation from peer reviewed literature to support its thirteen conclusions and is 37 pages in length (http://www.tag.washington.edu/projects/ClimateBuildingBlocks_Final_Oct5.pdf).

The creation of the Climate Change Building Blocks mimicked closely the development of a Shared Vision model. The initial draft of the Building Blocks paralleled the construction of a mock model that is frequently used in shared vision planning. After its construction, each of the major themes of the Building Blocks were debated thoroughly by the Committee until there was consensus that the Building Block was not only scientifically sound, but represented the expressed concerns of the Committee. The seven month period of discussion was typical to the process that occurs in the construction of a shared vision model.

Research Tasks

Once a consensus was reached that climate impacts would be significant and should be included in the evaluation of regional water supply and demand, specific procedures for evaluating these impacts were necessary. The committee entrusted the researchers at the University of Washington to create three items with their guidance: 1) an estimate of the anticipated changes in temperature and precipitation in the region for the decades surrounding the years 2000, 2025, 2050, and 2075, 2) an estimate of the anticipated changes in regional streamflow, and 3) guidelines for using this information in a regional framework to evaluates water supply and demand. Approximately six months later, the committee added three more tasks: an evaluation of the potential impacts of climate change on groundwater, an evaluation of the potential impacts of climate change on cloudy weather during summer months, and the development of a web-based access system to distribute these data.

The details of all of these tasks are beyond the scope of this paper, however, it is informative to note the interplay between the use of computer models, climate forecasts, decision frameworks, and the Committee. Like many current planning processes today that involve stakeholders, the Committee was not willing to simply provide a work statement to the researchers and then accept the researcher's result. Rather, the committee wanted to be informed on the approach that was to be used, understand the model and model assumptions that were to be used, provide evaluations along the course of the research, and to be involved in the final reporting of the research.

The specific steps included in developing the climate impacted streamflows alone involved: 1) selecting appropriate emission scenarios, 2) selecting appropriate GCMs, including the appropriate number of models, determining the "downscaling" technique to be used to translate the GCM data to local, watershed data, 3) the calibration of watershed models, 4) creating of the climate impacts streamflows, and 5) evaluation of streamflows to ensure quality control. Each step required explaining to the committee the range of potential options and the rationale for the approach chosen.

Conclusions

Shared Vision Planning is a process that integrates public participation, discipline water resources planning, and computer modeling to improve and streamline water resources planning.

Since it inception, one tenet of Shared Vision Planning has been to make use of models developed by stakeholders as a means to ensure the proper use of model results in decision making.

In the case of evaluating climate change, complex models that are not well understood by the water planning community are playing a significant role in evaluating climate impacts on water resources. If Shared Vision Planning is to effectively incorporate these models, adjustments must be made. The use of climate models requires further diligence in engaging stakeholders in defining the assumptions of the models to be used and in their interpretation. Unlike shared vision planning and modeling in the past, stakeholders will not be part of the model construction process but their trust still must be garnered. Experience in the Pacific Northwest indicates that stakeholders can gain confidence in such model and incorporate them into their analyses, but that even more time is necessary to gain their acceptance than in using simpler models.

Table 1- Climate Change Building Blocks

<u>Impacts of Climate Change on Temperature</u>

Building Block 1 – The global average temperature has increased during the 20th century and is forecasted to increase in the 21st century.

Building Block 2 – Warming in the Puget Sound Region has increased at a faster rate during the 20th century than the global average and increases in temperature are forecasted to continue.

Building Block 3 – Increased surface temperatures in the Pacific Northwest will increase the rates of evaporation and transpiration (evapotranspiration).

<u>Impacts of Climate Change on Precipitation</u>

Building Block 4 – Global precipitation is projected to increase in the future, although there is less certainty in predicting changes in precipitation than in temperature.

Building Block 5 – The occurrence of heavy precipitation events has increased over the U.S. during the 20th century. This trend is projected to continue during the 21st century.

<u>Impacts of Climate Change on Snowpack and Glaciers</u>

Building Block 6 – The loss of snowpack and glaciers in the Pacific Northwest mountains has been due to increased temperatures in the 20th century.

Building Block 7 – Forecasted increases in temperatures associated with climate change will further reduce snowpack and glaciers in the Pacific Northwest mountains.

<u>Impacts of Climate Change on Streamflows</u>

Building Block 8 – Climate change is projected to increase winter flows and decrease summer flows in snowmelt influenced river systems of the Pacific Northwest, particularly transient watersheds.

Building Block 9 – Climate change is projected to increase the frequency of flood events in most western Washington river basins.

Building Block 10 – Climate change is projected to increase the frequency of drought events in the Pacific Northwest.

<u>Impacts of Climate Change on Sea Level Rise</u>

Building Block 11 – Climate change is forecasted to raise global mean sea level in the 21^{st} century.

<u>Impacts of Climate Change on Salmonid Habitat</u>

Building Block 12 – Climate change is forecasted to increase temperatures of rivers, streams, lakes, and river mouth estuaries in the Puget Sound region.

Building Block 13 –Climate change, as described in Building Blocks 1-12, is forecasted to contribute toward stream flow and temperature conditions that have been shown to negatively impact freshwater and estuarine habitat of most species of salmonids in the Puget Sound watersheds.

Incorporating Modeling into Decision-Making for a Comprehensive Aquifer Management Plan: A Facilitator's Observations on Idaho's Eastern Snake Plain

Diane Tate
CDR Associates

Introduction

Supply of and demands for water are out of balance in Idaho's Eastern Snake River Plain. Conflicts among water users and between water users and the State have arisen over the process and impacts of conjunctive management of surface and groundwater resources under Idaho's prior appropriation doctrine. After decades of litigation, the State's Legislators asked the Idaho Water Resource Board to create a Comprehensive Aquifer Management Plan (Plan) to ease conflict and design a path to an improved aquifer, and improved relations among those that rely on it for their lives and livelihoods.

This paper provides background information on a case study to be presented by Diane Tate of CDR Associates during the workshop on the design and practice of Computer Aided Dispute Resolution (CADRe) for water resource management. The Idaho Water Resource Board (IWRB) retained Ms. Tate and Jonathan Bartsch of CDR in August of 2006 to facilitate development of a Framework for the Plan, and the creation of the Plan itself. Much of the information presented in this background document comes from the Framework approved by the IWRB in February 2007, and further information is available on the project website (www.espaplan.idaho.gov).

Physical Description

The Eastern Snake Plain covers 29,000 square miles in southeastern Idaho – approximately 35% of the State's land area, and all or part of 20 counties. The Snake River itself originates near the continental divide in Yellowstone National Park. It enters Idaho at Palisades Reservoir, and joins with the Henry's Fork River near Rigby. The ESPA – or the Eastern Snake Plain Aquifer – underlies 10,000 square miles of the Eastern Snake Plain, from Ashton to King Hill. Comprised of layered basalt, the aquifer is thousands of feet thick in some places. Groundwater flows generally northeast to southwest, and interacts with surface water in many locations. Water discharges to the river through thousands of springs along canyon walls and underneath the riverbed. Similarly, river water descends into the aquifer from many locations along the Snake's winding path.

Charge from the Legislature

Senate Concurrent Resolution No.136, passed by the Idaho Legislature in April of 2006, requested that the IWRB "expeditiously pursue, with support from the Idaho Department of Water Resources (IDWR), development of a comprehensive aquifer management plan for the Eastern Snake River Plain Aquifer for submission to and approval by the Idaho Legislature." The Resolution directed the Board to solicit public input regarding development of the "goals, objectives and methods" for aquifer management from "affected water right holders, cities and counties, the general public and relevant state and federal agencies." The Legislature also asked the Board to provide a status report during the next legislative session, together with a "framework for the plan, including appropriate interim goals and objectives in accordance with state law, a method to fund implementation of the plan and a time schedule for finalization of the plan."

In Concurrent Resolution 136, the Legislature listed factors driving the need for a comprehensive aquifer management plan, including:

- Reduced spring discharges and areas of declining aquifer levels resulting from extended drought, changes in irrigation practices and ground water pumping;
- Conflict between water rights holders stemming from insufficient water supplies to satisfy existing beneficial uses;
- The threat to the state's economy posed by ongoing conflict between water users;
- Resources already committed to the Conservation Reserve Enhancement Program (CREP);
- Previous actions taken by the Legislature to manage the ESPA, including legislation to create water measurement districts and groundwater districts, and previous funding for project implementation and mediation between parties;
- Previous actions taken by IDWR, including the expansion and creation of water districts for the purposes of conjunctive administration;
- The authority vested in the Board to cooperate in water studies, planning and research, and the work already done by the board to inventory data and information related to the ESPA;
- The good faith efforts of water rights holders to contribute to a resolution to the conflict; and
- The determination of the legislature to facilitate and encourage a resolution of the surface/groundwater rights conflict that respects existing water rights and protects the welfare of the people of the state of Idaho by ensuring the aquifer is managed in accordance with state law.

The IWRB hired CDR Associates to provide neutral facilitation assistance in the development of a Framework. CDR Associates initiated the Framework process by conducting over 90 in-person and phone interviews with affected water rights holders and other stakeholders in August and September, 2006. The Board held public meetings in October 2006 and January 2007 to receive input on the ESPA Framework process, and convened a series of working group meetings to develop the management alternatives presented in the final document. The facilitators invited everyone interviewed during the Framework and all public meeting attendees to participate in the working group meetings. Approximately 45 people attended each of three meetings.

The final Framework outlined goals and objectives for aquifer management, management alternatives (actions to increase supply or manage demand), proposed funding strategies to implement management actions, and suggested interim measures to be taken during development of the detailed Plan. The Legislature heard presentations from the Board and facilitators regarding Framework content and process in February and March, and appropriated funding to continue with development of a Comprehensive Management Plan for the Eastern Snake Plain Aquifer.

The IWRB established an ESPA Advisory Committee to develop recommendations for the Plan, with 32 stakeholder representatives nominated by stakeholders and confirmed by the Board and 7 agency participants. The Advisory Committee held their first meeting in May 2007, and meets on a monthly basis.

Stakeholders

The majority of ongoing litigation in the Eastern Snake deals with disputes between holders of senior and junior water rights. This includes canal companies holding both natural flow and storage rights within the surface water system, municipal and agricultural groundwater pumpers, and spring water users. Also at the table are federal and state agencies, including those that protect fish and wildlife as a part of their public trust responsibilities. The IWRB also included business interests, county governments, land developers, and hydropower producers in the membership of the Advisory Committee.

Ongoing Modeling Efforts

Since the 1970s, state and federal agencies, universities and private interests have developed groundwater flow models of the ESPA for various purposes. The University of Idaho developed the first numerical model of the aquifer for the Idaho Department of Water Resources (IDWR) and the U.S. Bureau of Reclamation. IDWR has used various versions of this model as a planning and management tool for over twenty years. Researchers converted the model to MODFLOW in 1999, and modified code to improve representation of the physical system. The current version is known as the Enhanced Snake Plain Aquifer Model (ESPAM)

The ESPAM was created with extensive review and input from the Eastern Snake Hydrologic Modeling Committee (ESHMC) during the period from 1999 through June 2005. The ESHMC is comprised of professionals working on water issues on the eastern Snake River Plain. Regular members include agency representatives (Idaho Department of Water Resources, U.S. Bureau of Reclamation, U.S. Geological Survey, U.S. Fish and Wildlife Service), industry representatives (Idaho Power), researchers (University of Idaho, Idaho Water Resources Research Institute) and private consultants representing water users on the eastern Snake River Plain. The ESHMC was formed in 1998 and was a follow-on to the previous Idaho Technical Committee on Hydrology (ITCH) which had a similar function. The ESHMC was originally formed to allow researchers and water users a forum for discussing water issues and research on the eastern Snake River Plain and is chaired by the Idaho Department of Water Resources.

Model reformulation was funded jointly by the State of Idaho, Idaho Power and the U.S. Bureau of Reclamation, with in-kind services provided by the U.S. Geological Survey. The ESHMC oversaw the reformulation of the model, with the actual modeling done by the Idaho Water Resources Research Institute (IWRRI) at the University of Idaho. IWRRI presented major design alternatives to ESHMC members for discussion and guidance. Model development was accomplished in an open environment, with acceptance of design input from all committee members, in an attempt to allay concerns regarding technical bias. In the Framework, the IWRB recommended use of this model, which continues to be updated and improved, to quantify and analyze the potential benefits and other impacts of management alternatives to be explored during the development of the Plan.

Bringing the Advisory Committee and the ESHMC Together

In July of 2007, the ESPA Advisory Committee and the ESHMC began discussions on how best to work together to accomplish their mutual goals. The questions being considered by the Advisory group that may involve consultation with the modeling committee include the following:

- How can the State quantify targets for management of the aquifer?
- What combination of management actions will most likely meet the targets?
- How could the hydrologic future be different from the past? What impacts would climate variation, changes in crop mix, changes in agricultural practices, shifts in commodity prices, etc. have on management actions?
- If an adaptive management strategy is pursued, how can the model help?

Before the Advisory Committee can articulate detailed questions for the model, however, basic education must take place. Over the next few months, committee members will be asking modelers to help them explore the following questions:

- What can this model do? What questions can it answer? What questions is it not suited to answer?
- What assumptions does the model include?
- What are the limitations of the model?
- On what scale does the model operate?
- What are the inputs to the model, and what are the outputs?
- During the calibration period, how does the model compare to observed data?

Challenges include working with one established group with limited membership, and another that is brand new with a diverse group of stakeholders. However, the facilitators believe that linking the modeling and plan development processes is essential, because the model cannot make policy choices, and the committee making those policy choices cannot understand potential impacts of decisions without the model.

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Solving urban watershed problems in Los Angeles through the use of collaborative planning

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INTRODUCTION

In 1999, the City of Los Angeles (City) embarked on a unique approach of technical integration and community involvement to guide policy decisions and water resources facilities planning. The Integrated Resources Plan (IRP) incorporates a future vision of water, wastewater and runoff management in the City that explicitly recognizes the complex relationships that exist among all of the City's water resources activities and functions. Using a holistic, watershed-based planning process, the IRP was a departure from the City's traditional single-purpose planning efforts for separate agency functions, and it will result in greater efficiency and additional opportunities for citywide benefits, including environmental restoration and increased quality of life.

The drivers for the IRP were significant, and included:

1. Reliability of wastewater collection, treatment and disposal system
2. Reliability of water supply, given that half of the City's water originates hundreds of miles away
3. Poor water quality of receiving waters, such as oceans, bays and rivers
4. Rising cost of providing water, wastewater and stormwater management services
5. Lack of public trust in city officials
6. Pending regulations concerning TMDLs
7. Lawsuits by environmental groups

The IRP sought to accomplish two basic goals in developing an implementable water resources plan:

1. Integrate water supply, water conservation, water recycling, and runoff management requirements and issues with wastewater facilities planning through a regional watershed approach; and

2. Enlist the public in the entire planning and design development process at a very early stage, beginning with the determination of policy recommendations to guide planning.

METHODOLOGY

The IRP was divided into two phases:

Phase I (completed in 2001): focused on defining the future vision for the City by developing a set of guiding principles to direct future, more-detailed water resources planning.

Phase II (completed in 2006): Focused on the development of a detailed facilities plan for wastewater and stormwater, as well as a recycled water master plan, environmental impact report, and financial plan.

Recognizing that the level of analysis and decision-making would be different for the two phases, an overall decision process methodology was developed (see Figure 1). Based on the principles of strategic and tactical planning, the first phase of the IRP would use a high-level systems simulation model, while the second phase would use more detailed hydrologic and hydraulic models specific to wastewater and urban runoff systems. The second phase would also rely on a multi-attribute tool that would be used to interpret results and match stakeholder preferences with performance of the various alternatives.

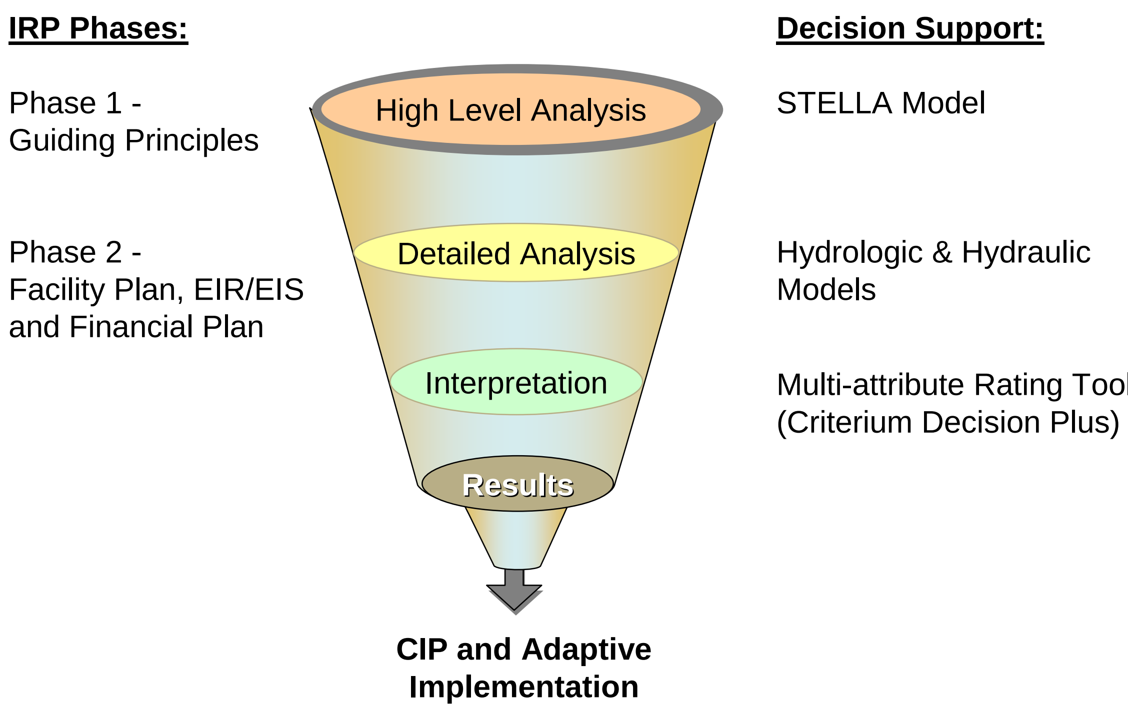


Figure 1
Overall Analytical Process for IRP

Both phases of the IRP evaluated alternatives and utilized stakeholder preferences to rank those alternatives. Phase 1 evaluated conceptual alternatives in order to develop a long-term vision, and to set policy principles that would be used to guide more detailed planning in Phase 2. Phase 2, in contrast, evaluated very specific integrated alternatives in order to develop facilities plans for water, wastewater and runoff.

One key aspect of the planning process was to separate the "why" from the "how." Often stakeholders come to a process with their positions firmly identified. These stakeholders want to jump to solving the problem (e.g., the "how"), rather than define what the problem is (e.g., the "why"). This was the case with the IRP. Many stakeholders came to the process with their "pet" projects or with the notion that no projects should be built (in order to control growth).

Therefore, at the start of the process, stakeholders were asked to put their positions aside and define their values. Several facilitated workshops were required to accomplish this. For example, with persistent prodding we were able to get some stakeholders off of the position that "no projects should be built" to stating their implicit value of "protecting the environment" or "enhancing quality of life." Similarly we were able to get other stakeholders that wanted new facilities built to state their value in terms of "protecting public health" or "supporting economic growth." Moving stakeholders from positions to values offers a real chance for developing collaborative solutions and attaining consensus.

Once we were able to move stakeholders from positions to values, we could then focus on developing objectives and performance measures that would be used to evaluate alternatives. Figure 2 presents our method for keeping the "why" and the "how" separate until the timing was right to merge them.

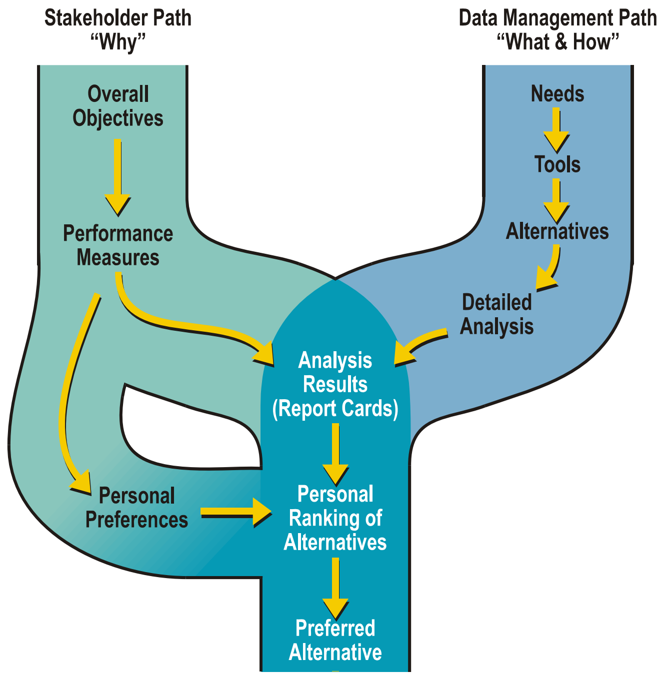


Figure 2
Decision-making Paths

STAKEHOLDERS

The City conducted an extensive citywide outreach effort in order to identify stakeholders. Mass mailing to community leaders representing many diverse interest groups such as homeowners associations, church groups, business owners and environmental groups was used to solicit participation. In addition, targeted invitations to the process were conducted for regulators and key stakeholders that the City knew would be important. From this extensive effort, over 1,100 stakeholders participated in the IRP.

The stakeholders were broken into three tiers:

- Steering Group
- Advisory Group
- Information Group

Members of the Steering Group represented the core stakeholder group. They committed to attending a total of 13 half-day workshops conducted over a three-year period. At these workshops, the Steering Group had the following roles:

1. To provide on-going input on technical, environmental and financial development of the project;

2. To help identify projects and solutions; and

3. To consider key project issues, such as facilities siting, implementation risks, and public

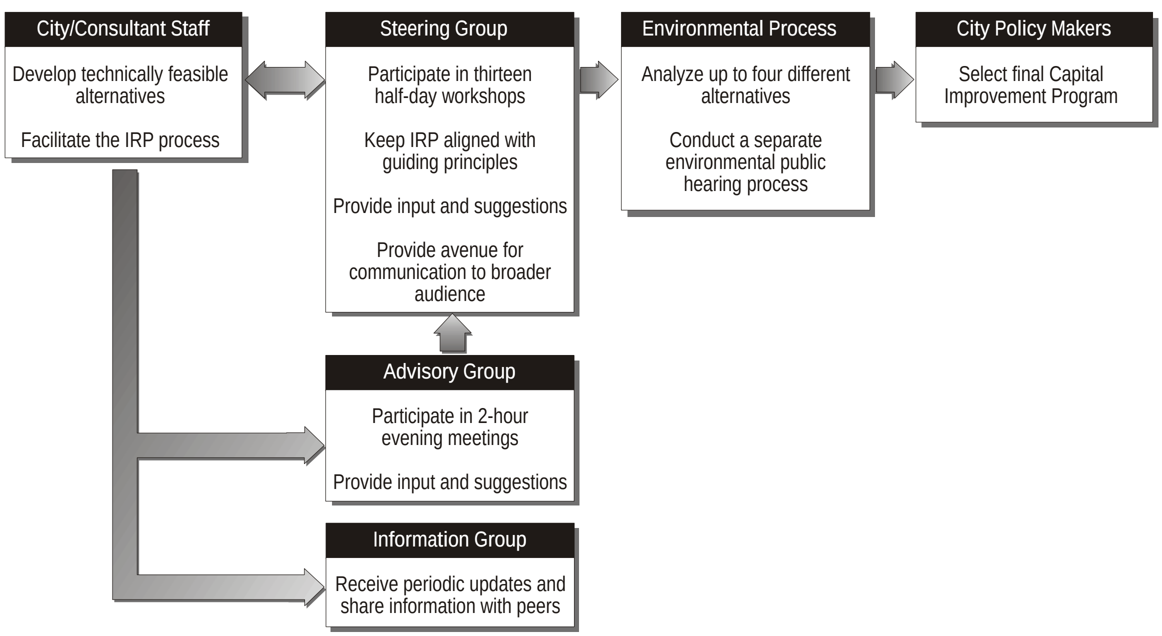
acceptability.

Members of the Advisory Group participated in evening workshops over the three-year period and had the opportunity to provide comments and suggestions and to make observations for consideration by the Steering Group and the City. Members also were expected to inform their colleagues in the organizations, companies, and/or agencies they represent about the major milestones and recommendations of the IRP efforts. A total of ten sets of Advisory Group meetings were held in seven different areas throughout the City.

Members of the Information Group received periodic newsletters to inform them of major milestones and recommendations of the IRP effort. A project website was also developed with polling features so all interested parties could track the progress of the IRP and provide comments.

Figure 3 illustrates the relationships between the City and the stakeholders.

Figure 3 – Stakeholder Organization



ANALYTICAL PROCESS

During Phase 1 of the IRP, a high level systems simulation model was built using STELLA. STELLA is commercially available software that uses object oriented programming. It can be used to represent systems that have elements of mass-balance and flows. For this project, it was used to test conceptual alternatives and educate stakeholders on how water resources in the City are linked. For example, it allowed stakeholders to see the water supply opportunities and water quality benefits by capturing rainwater and storing it. Or to see the water supply benefits of locating a new wastewater plant near potential users of non-potable quality water. Figure 4 presents the basic interrelationships of the City's water resources that were captured in the STELLA model.

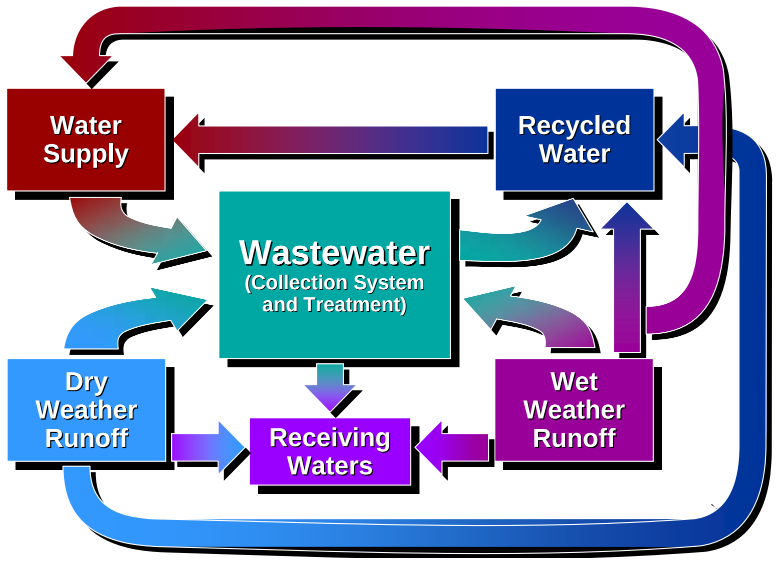


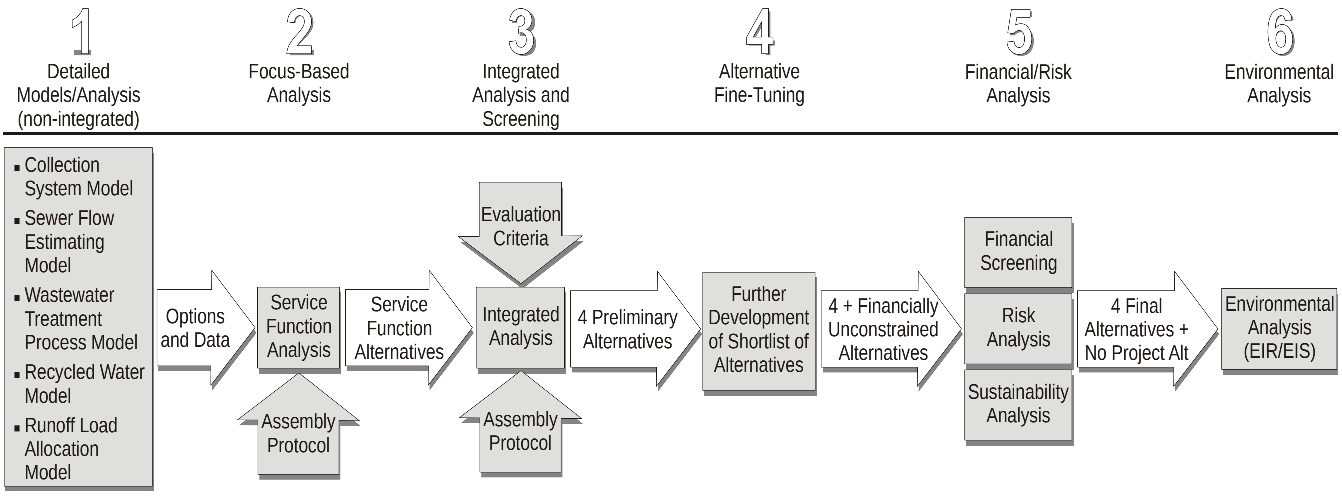
Figure 4
Interrelationship of City's Water Resources

The model was built in a collaborative setting, allowing stakeholders to review all critical model linkages and relationships. This helped to build trust because stakeholders saw this as "their" model and not a "black box".

For each conceptual alternative, the STELLA model produced output on costs, water quality, reliability of the systems, and other output such as increased open space. This analytical process helped stakeholders define policy principles that were then adopted by the City Council for use in subsequent and more detailed facilities planning.

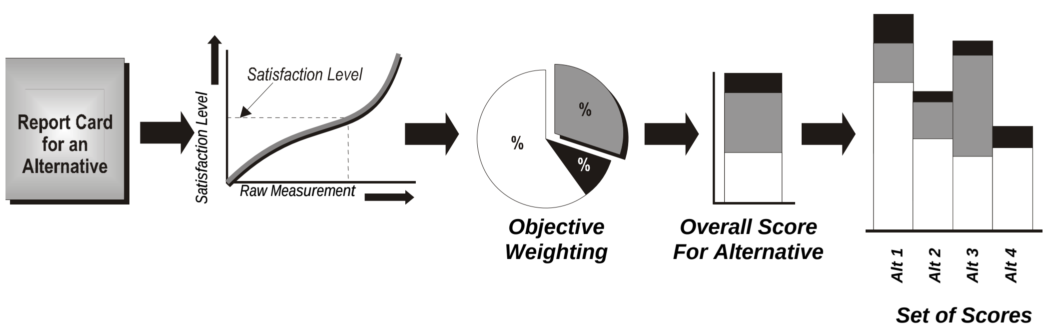
During Phase 2, detailed modeling was necessary for wastewater, stormwater and recycled water planning. Hydraulic models and hydrology simulation tools were used. Figure 5 presents the analytical approach used during this phase. Stakeholders were still very much a part of this process as well. They reviewed technical output and even crafted technical solutions to be tested in the models.

Figure 5 – Phase 2 Analytical Approach



The last step in the analytical process was bringing all the pieces together. We used a multi-attribute rating technique and the commercially available software called Criterium Decision Plus to bring stakeholder preferences into the mix of alternatives evaluation. Figure 6 demonstrates this approach. For each individual stakeholder we kept track of how they would rank alternatives using their specific values (or criteria weights). This was most useful in reaching consensus.

Figure 6 – Method of Calculating Scores for Alternatives Analysis



OUTCOME

The outcome of this process was: (1) broad consensus on a preferred alternative from over 25 alternatives evaluated; (2) approved facilities plan and certified environmental document; (3) settlement of pending lawsuit on beach closures; and (4) voter approved City bond of $500 million to help pay for project implementation. The City also hailed the IRP as an excellent example of how collaborative planning should be conducted. The IRP was also a recipient of several state and national engineering excellence awards for planning.

Changing the Rules for Regulating Lake Ontario Levels

Bill Werick
Werick Creative Solutions

Overview

In September 2007, the International Joint Commission (IJC), a joint U.S. - Canadian organization created by the Boundary Waters Treaty of 1909, is expected to promulgate new rules for the regulation of Lake Ontario water levels. Barring extreme difficulties from public review, the rules would most likely go into effect in 2008. This would be the first time (to my knowledge) that the rules for regulating releases on a major North American water system have been changed in the last 30 years, despite the fact that changes to the rules have been under study on almost every major basin. The IJC used shared vision planning to develop and vet these rules, and the Lake Ontario case study now stands as the most technically ambitious and successful shared vision planning application. This paper outlines how the shared vision planning effort unfolded, and highlights the innovations, strengths and weakness in this particular study.

Background

The International Joint Commission (IJC) issued an Order of Approval in 1952 to build the St. Lawrence River Hydropower Project, including a dam across the St. Lawrence River that allows the IJC to regulate Lake Ontario water surface elevations and flows and elevations in the St. Lawrence River. The IJC has since 1963 used a written set of regulation rules called "Plan 1958-D", but about half the weekly regulation decisions are considered "deviations" from the plan. These deviations have been necessary for many reasons, most importantly, because the written plan does not work well when water supplies are much less or much more than the 1860 to 1954 supplies that were used to design and test the plan.

In 1993, the multi-year Levels Reference Study recommended that the "Orders of Approval for the regulation of Lake Ontario be revised to better reflect the current needs of the users and interests of the system." That study did not address environmental impacts, a use of water not identified or explicitly protected in the treaty, nor did it precipitate a consensus on how the current needs could be addressed while protecting traditional uses. In April 1999, the International Joint Commission informed the governments that it was becoming increasingly urgent to review the regulation of Lake Ontario levels and outflows. A plan of study was endorsed in 1999 and the study began late in 2000.

The original plan of study did not define how plans would be formulated, evaluated and ranked, or how researchers would design their work to fit into an overall evaluation scheme. Late in the first year of the study, I made a presentation of how shared vision planning could be used on this study. The presentation included an Excel model based on a STELLAA model developed for the five Great Lakes by Phil Chow and Hal Cardwell of the Corps' Institute for Water Resources. Thereafter the Board agreed that all subsequent planning work would be done using shared vision planning. A Plan Formulation and Evaluation Group (PFEG) was formed soon after, and

PFEG began to restructure the study with the aim of linking research, public input and decision making. In some cases, PFEG had to realign research that had already begun and assist in the design of studies that were not yet underway. In other cases, work was well along and PFEG used what was done.

The study

Figure 1, below, shows how the shared vision model (in blue) fit with the study research (in yellow). Research was conducted by seven technical working groups (TWGs), managing water information (the Hydrology and Hydraulics TWG) and six impact areas (coastal, navigation, hydropower, municipal and industrial water, recreational boating and the environment). The shared vision planning framework connected decision makers to experts and stakeholders:

- **Experts-decision makers.** Our planning process required all TWGs to conduct research that would support a quantitative connection between water levels and economic, environmental or social impacts. For the hydropower and recreational boating TWG's, this was a foregone conclusion and in fact, work along these lines was well along before shared vision planning was in place. But it took a substantial effort to shape environmental studies this way, and considerable tuning to re-shape the navigation and coastal studies.

- **Stakeholders-decision makers.** We asked the Study Board to hold six "practice" decision workshops to iteratively refine the criteria the Board would use to make its decision. Those workshops were conducted with stakeholders and often with commissioners present. These "fire drills" helped make sure that the Board understood what stakeholders wanted and helped stakeholders understand why the decisions were made the way they were.

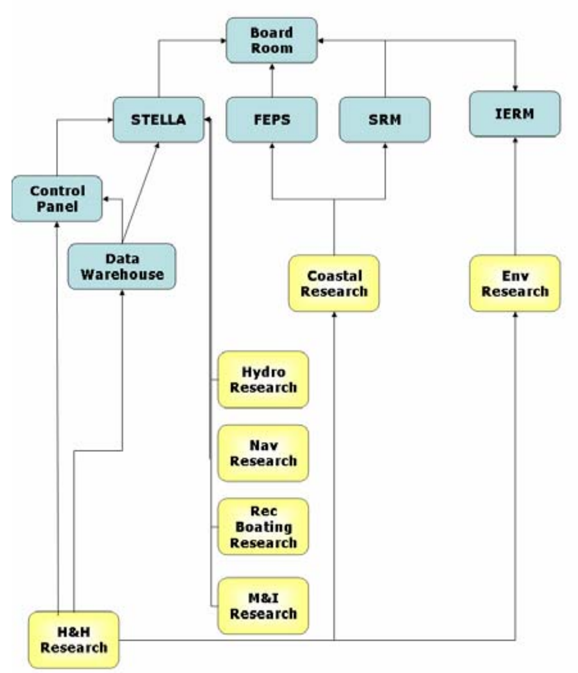


Figure 1. SVM Structure

- **Experts-stakeholders.** The study had already allowed stakeholders to participate in technical working groups even before starting the shared vision planning process. In the public TWGs -navigation, hydropower and M&I - stakeholders were represented by paid technical staff; in other impact areas, the stakeholder representatives were not as technically proficient. The shared vision planning process, especially the collaborative model building, had two primary impacts on the expert-stakeholder connection. First, it allowed experts to make sure they understood how stakeholders were impacted. Working with experts and stakeholders, we developed over one hundred hydraulic attributes such as seasonal water level ranges that were used to evaluate plans (especially in the early part of the study, before economic or environmental impact functions were complete). We met with groups of stakeholders around the study area and worked with them to design their own section of the shared vision model that contained the information they told us they would use to rank plans, with tables and graphs they helped design. Second, it gave stakeholders a better understanding of how the impact measurements were linked to water levels, not just in their own areas of interest but also for issues that stakeholders with conflicting interests supported.

PFEG worked with the Environmental Technical Working Group chairs to review over two dozen environmental research scopes and help establish mathematical relationships between water levels and a biological result. Dr. Joseph Depinto and Mr. Todd Redder of Limno-Tech, Inc. then developed a dynamic model relating water levels to the potential environmental impacts identified in the existing body of research subjects. Although they initially opposed the Integrated Ecological Response Model (IERM) environmental researchers eventually embraced it as their own and in workshop exercises, began to question their intuition when it differed from model results, rather than vice versa.

The model

There was considerable debate about what software to use to build the shared vision model. The final structure was a compromise that (in retrospective judgment) worked well, but was bent a little too much in the direction of researchers' preferences. The final SVM was a system of models, not just one software or file, but all the results were captured in a sophisticated Excel spreadsheet that became the face of the SVM for most study participants. That spreadsheet came to be known as the Board Room. The PFEG led the development of the model, with STELLA and Excel coding being done primarily by Bill Werick and Mark Lorie of IWR, and David Fay and Yin Fan of Environment Canada. A few other agency experts added elements to the STELLA and Excel models. Lay stakeholders sometimes were engaged in modeling workshops, but by their choice, none did any coding. Stakeholders trusted the models because they were very familiar with the modeling effort, not because they performed it, and because they knew there was no censoring or significant time delay in reporting modeling news. When we found a big mistake, everyone knew about it the next day.
The planning process percolated through various models in this fashion:

- Researchers developed algorithms connecting impacts to water levels or flows using field data and their own analytic procedures. For instance, stage-damage relationships in the lower St. Lawrence River were developed using GIS that estimated the level of flooding on individual homes at a range of water levels. Information from these models was then used to develop damage functions in the shared vision modeling system.

- Board members, stakeholders, experts in various fields other than regulation plans and paid plan formulators would propose new regulation plans in conceptual terms and then the plan formulation team members would code the concepts. There were four formulation teams that experimented in four categories of plans: modifying the existing rules; optimization schemes; "natural" regulation, and coding of plan concepts offered by others. Each team would use whatever software they wanted to code the rules. The output, a 4,848 quarter-month time series of releases, was then pasted into an Excel model, a part of the shared vision model called the “Control Panel”. That release set defined a unique alternative plan.

- Plan formulation was also used to explore the potential to solve problems, even with plans that would be impossible to implement. “Fence post” plans were also developed, with each fencepost defining a plan that was designed to serve one interest no matter the effect on other interests. These fence posts defined the decision space, and showed the limits of our ability to control water level related impacts. Most importantly, we showed that we could not reduce damages to Lake Ontario shoreline properties much more than we already had. In a similar fashion, we formulated “perfect forecast” versions of alternative plans so that we could quantify the potential benefits of better forecasts.

- Water levels and most impacts would then be calculated in a STELLA model dynamically linked to two spreadsheet input models, the Control Panel and Data Warehouse. After the STELLA model was run, tables from that model would then be copied and pasted into a third Excel model called the “Post Processor”. The post processor included macros and tables that could be used to call external models that did the rest of the impact evaluations including Lake Ontario coastal impacts (FEPS), St. Lawrence River shore protection damages (SRM) and the environmental impacts (IERM). Those three models are described very briefly below.

- FEPS (Flood and Erosion Prediction System) is a proprietary C++ model developed by Baird Engineering during previous investigations into Great Lakes erosion and flooding research. FEPS uses water level erosion relationships developed using a very data intensive erosion model called COSMOS at several representative cross-sections around the lake and then applies the results over and over using reach specific parameters around the entire Lake Ontario coastline. Flooding damages are based on water levels and wave heights, capturing both inundation and wave impact damages, and shore protection structure damages are assessed using erosion and flooding models. Erosion at any moment in time is serially dependent on the water levels experienced in the years preceding that moment. Hence, a shore protection structure becomes more vulnerable to damage as erosion eliminates protective beachfront, and it may fail in the eighteenth year of simulation under one plan and in the twenty-fifth year under a different plan. Run time for the FEPS model was about three minutes.

- SRM (Shoreline Response Model) was a proprietary model developed by Pacific International Engineering to assess the effects of different releases on shore protection built along the banks of the St. Lawrence River. Our evaluations showed that all regulation plans being seriously considered had about the same amount of river shoreline damage. Once this was established, this model had little additional relevance in the evaluation process. Runtime was about a minute.

- IERM (Integrated Environmental Response Model) a Visual Basic model, was itself a collection of sub-models. When called from the post processor, the IERM would present a window announcing which sub-model was running. Run time was about 80 minutes on a modern laptop.

Several people had this model suite on their computers and used it to evaluate models and to check the evaluations other people had done. All of the modeling described above was used to evaluate plans using 101 years of quarter-monthly data. All these evaluations were designed around the 101 year, 4,848 quarter-month structure. When we first tested the alternatives with climate change and stochastic information, we had to manipulate the hydrologic input datasets to this structure. Twenty-nine year climate change datasets had been developed using the 29 years of historic data for which we had enough collateral information, such as precipitation and evaporation, to downscale and interpret global circulation model outputs. We simply repeated these 29 year datasets until we had 101years. The study developed a 50,000 year stochastic hydrology, and at first we snipped particular 101 year "centuries" from this large data file to form four 101 year quarter-monthly datasets that represented extremes in the stochastic data, and put these snippets in the Data Warehouse spreadsheet so they could be used in this same way to evaluate plans with alternative hydrologic assumptions. Later, a full stochastic analysis using 495 101 year sequences was also done using FORTRAN code translated from STELLA equations and a variation of the FEPS code.

The four plan formulation teams compared results and benchmarked each others' plans, both over the internet and in face to face workshops. This developed a rich understanding of how the system worked, and allowed us to share breakthroughs wherever they were made. Stakeholders had complete access to these sessions, and while few took part in them, stakeholders who did take part helped spread news of plan formulation, and this helped people trust the process. Hundreds of alternatives were tested with the historic evaluations, which could take from two minutes (STELLA only) to ninety-minutes (STELLA, FEPS, SRM and IERM). The full stochastic analyses took over a day of computing time to run and these runs were done only for plans that were of particular interest. But the final economic benefit analyses were based on discounted values using the full stochastic evaluations. The discounting captured the reality that erosion happens no matter the regulation plan, so the only difference was how fast it happened (plans that slowed erosion down had positive economic benefits). Had we simply discounted damages using the 20th century "historic" hydrology, the differences between plans would have been muted and distorted, since the wettest and most damaging period came in the last three decades of the century. Instead, the stochastic version of the model recorded damages for each quarter-month of the 4,848 quarter-months in each of 495 101 year "centuries" and so was able to produce an average expected damage for each quarter-month into the future. These average damages were then discounted. A sensitivity analysis allowed various planning horizons and interest rates, but the final report was based on 4% discount rate and 30 year evaluation period. Figure 2, below, shows that Lake Ontario water levels could be nearly three feet higher and lower than recorded levels even under the current regulation plan, which seeks to compress lake level variation.

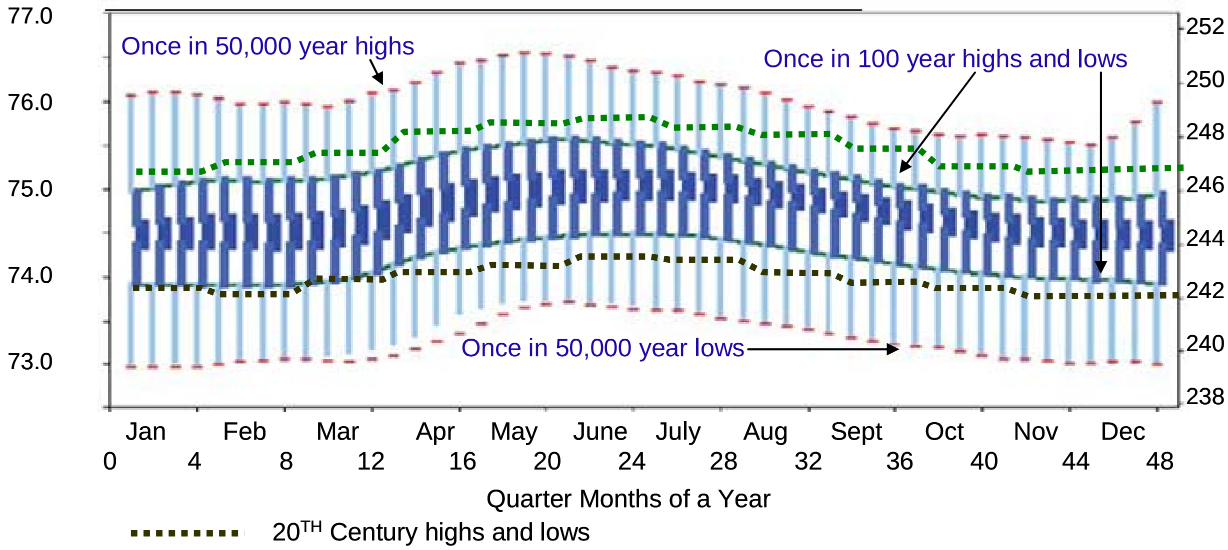


Figure 2. Range of possible Lake Ontario levels through the year under the current regulation rules

The Essential Conflicts

The IJC receives a fairly reliable stream of complaints from some stakeholders because they live or keep their boat in a place which cannot be made satisfactory through regulation. As is true in most places, people have built along the coast based on recent water levels, not on the inevitably higher and lower levels that will come after building. There are a few hundred homes along the Ontario and St. Lawrence coast that will receive at least nuisance flooding no matter how Lake Ontario is regulated. Similarly, there are a few hundred boat slips that will not offer enough draft when water levels are merely normal. This was probably exacerbated by the generally high levels in the last few decades, which coincided with the increase in boating ownership and use. On the other hand, drought management plans that held water on Lake Ontario as long as possible worked for people around the lake and along the river; large short term releases to create normal depths in the river often hurt people along the river because those releases drained Lake Ontario so much that severe release restrictions were needed when natural flows were even lower.

The main conflict that could be affected by regulation was between shoreline property damage and wetland plant diversity along Lake Ontario. Compressing lake level variations helped property owners but created a narrow band of transition between submerged and upland species. There is also a conflict between coastal damage above and below the dam. The damage risk on the river is by far the greatest when winter ice and snow in Quebec melts. If Lake Ontario is high at the same time, the release decision must balance the near certain river damage from higher releases against much larger potential damages along the lake if wind storms occur while lake levels are high.

The Results

The IJC asked the Study Board to provide options, not one recommendation for a new regulation plan. In their final report, the Board gave the IJC three regulation plans labeled A+, B+ and D+. Of the all the plans that met the Study Board requirements, A+ maximized economic benefits, B+ maximized environmental benefits, and D+ minimized sectoral losses. No plan was found that improved on the current plan in every sector; tradeoffs, sometimes fairly small, seemed unavoidable. We tried but could not reduce coastal damages from the B+ plan. It would cause an average of about $2.5 million per year in damages, an average created by no damage in most years but tens or hundreds of millions of dollars damage every 20-30 years. We showed that we could eliminate these damages with perfect forecasting in the fall of local spring runoff into Lake Ontario (that is, not the flow from the Upper Lakes, which is fairly predictable). That creates hope that better forecasting, even if not perfect, would allow us to develop a risk management strategy for fall levels that would keep most of the environmental benefits and not cause more coastal damage than we would expect to experience under the current plan.

Lessons Learned

The Lake Ontario study, in my opinion is the best water resources study ever done. A six page paper cannot do it justice. But it was not perfect. The study was the subject of some criticism from a National Academy peer review. While I believe most of the criticisms were the result of a lack of communication and the limited time the reviewers had to review this work, we did agree that we had failed to do some traditional documentation and had not communicated our risk and uncertainty analysis well. We've taken steps to address that since.

In retrospect, I believe the FEPS and IERM models could have been modeled in Excel or STELLA. Subtle misunderstandings and deeply buried errors in the FEPS modeling – an otherwise impressive modeling effort – caused a complete mid-study shift in plan evaluation, as we found that alternatives that seemed promising were not. And while there were iterative models in the IERM that could not have been done efficiently in STELLA or Excel, these sub-models did not play a significant role in decision making. The wetland plant diversity model, which was crucial in decision-making had been modeled successfully in STELLA. At study's end, we found discrepancies between the IERM and the original model developed by the biologist who had developed the algorithm linking water level sequences to plant diversity. The differences were small, caused by subtly different interpretations in code of concepts like "the highest three quarter-month elevations during the summer". After the study was completed, shared vision modelers developed Excel coding that we believe is faithful to the concept, but it has not had the broad review and endorsement it would have had if it had been done during the study. Throughout the history of shared vision modeling, I have never replicated a black box model in STELLA or Excel without finding errors or misdirection in the black box. Self-interested modeling technicians are quick to condemn the admittedly limited ability of STELLA and Excel to do iterative "do-loop" logic, but this has to be balanced against the fact that most black box models rarely get one good peer review, while the typical shared vision model is closely scrutinized by dozens of people and is used so often that mistakes are more prone to show up and get cleared up.

Finally, the Lake Ontario study gave us a chance to implement the "informed consent" decision process, a formalization of decision steps that grew out of experimentation with decision processes in shared vision planning studies over the last dozen years. I think the Lake Ontario informed consent process will serve as a model for future studies, although it might need to be scaled down for shorter studies with more modest budgets. The informed consent process is premised on the notion that decision makers, experts and stakeholders must practice the decision from about mid-study, using available information. Each practice decision on this study was observed and criticized both by the Study Board itself and by a consultant, Frank Lupi of Michigan State University.

Conclusion

We will not know for months whether the IJC will be able to implement the new regulation plan, but I am optimistic that this will happen. It may seem faint praise to say that a study this long and expensive and recent is the best ever done, but I think it is a useful provocation to make. For me, and I hope for others, it will serve as a standard against which we measure the effectiveness of the processes and tools of our planning and dispute resolution trade.

Drought Preparedness in Northern California
People, practices, principles and perceptions

Ane D. Deister
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Placerville, CA

Introduction – Setting the stage

California is known in for many things. Sunshine, agriculture, Hollywood, aerospace, Silicon Valley, beaches, kayaking, cars, music, fancy homes, snow-boarding, racial conflicts, fishing, electronic devices, political dynamics, educational institutions, and communities that provide the backdrop for television shows viewed across the country. These California icons and many more are seemingly different, but they are united by one thing – they all need water. Yet, many of the folks at the top of their game in most of the state's commercial and industrial enterprises are probably not aware that the state's water supply is riddled with many challenges and uncertainties. Not unlike many other parts of the country, most of the water-rich areas are located some distance from the largest population centers. And, not unlike many other areas in the west and throughout the country, California's water supplies are subject to naturally occurring droughts that can extend close to a decade in duration.

Northern Californians are intensely interested in water supply and may comprise some of the most interested and engaged members of the general public. While the days of "we" and "they" are beginning to mellow slightly, there is still a sense of entitlement by Northern Californians regarding the water supplies that originate in their back and front yards and flow downstream to the high population centers in Southern California. El Dorado County covers the area between Sacramento, the state capitol, and South Lake Tahoe. It is a strikingly beautiful area that still sports vast areas of forest land, supporting rich wildlife and fish populations and serves as a key bedroom community for people working in California's state capitol. In the past El Dorado county was known as the site of California's gold discovery and today the gold has been replaced with acres of tree crops, burgeoning vineyards and wine production, water-based recreation, and systematic residential and commercial growth.

In 1976-1977 the phrase 'if it's yellow let it mellow; if it's brown flush it down' descriptively pronounced the conservation measures northern Californians were taking to cope with the worst drought of historical record. In the late 1980's and into the 1990's, over the course of about 7 years, California experienced a daunting prolonged drought that heightened the water supply awareness for many water users. In 1998 and again in 2005 California's Department of Water Resources modified the requirements for water utilities regarding the legislatively mandated Urban Water Management Plans. The plans must be updated at least every 5 years and, since 2005, must include a chapter on water shortage contingency plans and address a 50% water reduction situation.

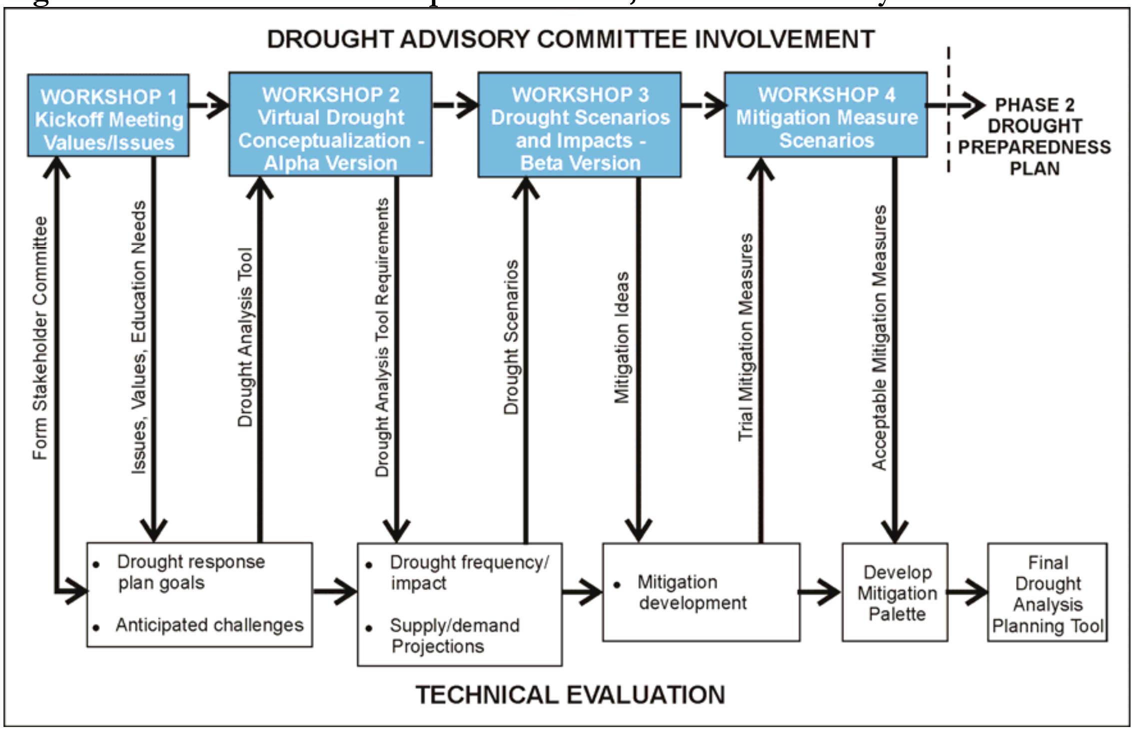
Today, California's Governor has elevated water supply issues substantially with his direct involvement in climate change issues and global warming regulations. With the experiences of Northern California, and now coupled with the statewide spotlight of our Governor, it was certain that a comprehensive drought preparedness program for El Dorado County had to be something that relied on intensive collaborative dialogs, data sharing and significant scenario planning.

In 2004 the El Dorado Irrigation District and El Dorado County Water Agency joined together to update previous drought and conservation plans and develop and fund a comprehensive drought preparedness program. A key part of this program has been development of a Shared Vision Model and collaborative dialogs with many interested parties, or stakeholders, and both local and national experts.

<u>Shared Vision Planning – using diverse views to strengthen the whole</u>

One of the characteristics of an engaged and highly interested community is the view by many participants that they are as knowledgeable and informed as practicing experts in the fields of climatology, water resource engineering, computer modeling, climatology, and other similar 'ologies'. Some may see that as a challenge; and others as an opportunity. El Dorado chose to see it is as opportunity, and worked to find a way to capture public input, incorporate scientific information, and develop 'what if's' to generate discussion on preferences and expectations. Developing a shared vision model allows diverse participants to weigh in early in the process, buy in at each stage, and ultimately support the products, and implementation when completed.
The shared vision model, also called SVM for short, takes advantage of new, user-friendly, graphical simulation software to bridge the gap between specialized water models and human decision-making. It is an effective way to integrate multiple factors into the process including potential economic, environmental and social impacts associated with droughts and contingency measures. It provides an integrated framework upon which sound drought preparedness decisions may reside.
Figure 1 graphically depicts the manner in which the drought preparedness participants developed a 'shared vision'. This vision considered the past drought experiences and economic impacts to El Dorado County residents and businesses, coupled with their concerns for future impacts considering climate change and the increasing demands for water throughout the state.

Figure 1. Shared Vision Development Process, El Dorado County California

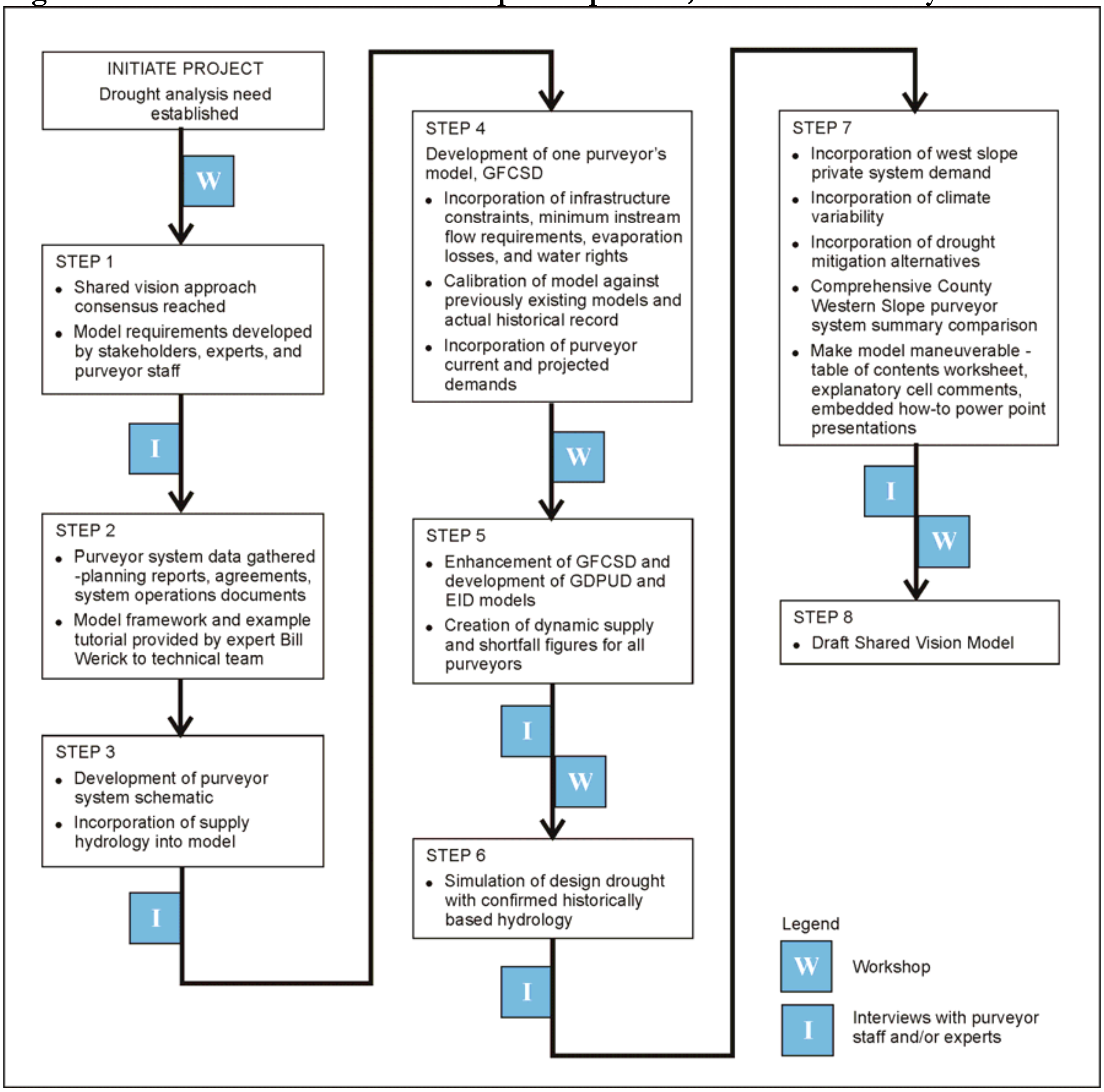


The key to acceptance by the diverse interest groups was an iterative, interactive process of data presentation, discussion of the data, sharing of personal experiences and rigorous scientific perspectives provided by several key experts. Having a stable of solid, well respected, nationally recognized practitioners to help guide the process resulted in serious, lively, and well versed communications. The expert team El Dorado used included: Dr. David Jones, former UC Berkeley professor and USGS state hydrologist, and current local winery owner; Dr. Jay Lund, UC Davis climate change professor; John Olaf Nelson, former water utility general manager and current water resource consultant; Bill Werick, former long time water resource expert with the US Army Corps of Engineers and present shared vision planning consulting expert; Dr. Donald Wilhite, Director of the National Drought Mitigation Center at the University of Nebraska at Lincoln and drought planning expert.

<u>Shared Vision Model Overview – clear, open, technical applications</u>

Moving from a conceptual shared vision into practical application involved the use of a Microsoft Excel based model. It allows users to review information and assumptions that may be embedded in the model, and provides flexibility to separate inputs and impacts for each water provider in a given area. Figure 2 graphically depicts the steps used in developing the SVM.

Figure 2. Shared Vision Model development process, El Dorado County California



Applying the model – success through simulations and transparency

Once the model was developed the participants worked collaboratively to apply the results of the intensive data analysis phase of the project and translate the science of drought into practical drought preparedness solutions. Through the use of 'virtual drought' simulations the group of experts and other participants tested the vulnerabilities of each water entity's supply management and delivery systems. Identifying predictable outcomes provides an objective basis upon which the group developed contingencies and mitigation measures to lessen and/or better manage the adverse impacts of drought on various community components.

The SVM process provides a graphical tool that incorporates key features important to consensus building and widespread acceptance, foundational to the project's success. The following qualities were realized through the SVM process:

- Transparency of diverse information, assumptions and decision factors
- Ease of use for both model experts and non-experts
- Ability to quantitatively predict shortfalls
- Clear depiction of the water utilities and providers in the area
- Ability to demonstrate the manner in which shortfalls would occur
- Ability to evaluate effectiveness of various drought responses
- Ease in updating the model tool
- Ability to test existing drought plans against proposed, improved plans
- Ability to integrate climate change scenario influences

The overall success of the drought preparedness project, beginning with an intensive drought analysis project and development of the Shared Vision Model for El Dorado County, was due in large part to the enthusiastic, informed stakeholder participation process. Consensus was reached through integration of financial, environmental, scientific, commercial, agricultural, and social equity concerned stakeholders who worked collaboratively in the Drought Advisory Committee. The close attention to detail, which was time consuming, led to enhanced public confidence and buy in. The end result is El Dorado County is better prepared for the next inevitable drought and will be able to serve the public with assurance that their expectations and concerns were valued and integrated into the agencies' business operations.

Biographical Information on CADRe Workshop Participants

Name: Steve Ashby
Title: Research Hydrologist
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Bio: Mr. Ashby has spent twenty-eight years experience as a Physical Scientist and Research Hydrologist in the Environmental Laboratory, U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. His Recent research has focused on the design and conduct of water quality studies in freshwater and coastal ecosystems, watershed assessments, and planning and implementation of ecosystem restoration projects. His other research activities have been conducted in watershed initiatives that involve state and local agencies and interactions with CE Districts and Divisions (e.g., Big Bear Lake Municipal Water District and CESPL; Lake Allatoona Preservation Authority and CESAM; Ducks Unlimited and CENAB; Delaware River Basin Commission and CENAP; Lower Mississippi River Conservation Commission and CEMVD; Upper Mississippi River Commission and MVD). These studies require multi-agency research and development collaboration for planning and implementation of resource management strategies. He is currently serving as the Program Manager for the System-wide Water Resources Program.

Name: Allyson Beall
Title: Ph.D. Candidate
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Bio: *Integrated sage-grouse and human systems model*- Model was built collaboratively with a conservation district for sage grouse management as part of their multi species habitat conservation plan. The model combines land use, habitat suitability and sage grouse life history and it provides interfaces that allow users to explore a variety of quantitative and qualitative parameters, and potential conservation alternatives.

Okanagan Basin, British Columbia – Co-facilitator for a participatory modeling project concerned with water resources, climate change and population growth.

Participatory modeling for environmental problem solving: Reports from the field - A cross case study analysis of participatory modeling projects. The analysis compares case studies to illustrate the flexibility of process and the effectiveness of a broad range of interventions. In addition to process protocol, the number of stocks contained in the model as a proxy for problem complexity was compared to the need of the process, the time spent, and the number of groups involved. This led to more questions which inspired an assessment of the following characteristics: 1) Interventions may take place anywhere on the "problem definition to solution producing" continuum. 2) Stakeholder involvement in the model building process varies; "the hands on" continuum. 3) The type of data required varies on the "qualitative to quantitative" continuum.

Participatory models can be useful tools for improving trust, reducing conflict, and helping to bridge the potentially conflicting world views of science and local knowledge. I see this workshop as venue to help expand the use of participatory modeling as a part of CADRe through the development of a network of practitioners with expertise in a variety of disciplines.

Name: Thomas W. Beauduy
Title: Deputy Director & Counsel
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Bio: Thomas W. Beauduy is the Deputy Director & Counsel of the Susquehanna River Basin Commission (SRBC), a federal-interstate compact commission with water resource management responsibility for the Susquehanna River Basin. Prior to joining the SRBC in 1997, Beauduy was in private practice specializing in environmental law.

He served as Executive Secretary to the Joint Legislative Conservation Committee in the Pennsylvania General Assembly from 1980-1985, and was a former Assistant Attorney General for the Commonwealth of Pennsylvania from 1978-1979. He has authored a number of Pennsylvania environmental statutes, among them the Pennsylvania Nutrient Management Act. He also served as the Pennsylvania Director of the Chesapeake Bay Commission, a tri-state legislative advisory commission, from 1985 to 2004.

Beauduy graduated from Rutgers University in 1975 with a B.A. in Political Science, and received his Juris Doctorate degree from the Dickinson School of Law in 1978. He has been an active member of the Pennsylvania bar since 1978.

Name: Elizabeth (Lisa) C. Bourget
Title: Secretary of the U.S. Section of the International Joint Commission (IJC)
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Bio: Lisa Bourget serves as Secretary of the U.S. Section of the International Joint Commission (IJC), a binational treaty organization responsible for helping prevent and resolve disputes primarily related to water and the environment along the Canada-U.S. border. The Commission assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality, as an independent and objective adviser to the two governments.

Prior to joining the IJC, Ms. Bourget was Engineering Director at Dewberry and Davis, a private engineering and architecture firm. Ms. Bourget received a BS in civil engineering from the University of Virginia and an MBA from Virginia Polytechnic Institute and State University. She is active in the American Society of Civil Engineers' Environmental and Water Resources Institute and is a registered professional engineer in the Commonwealth of Virginia. She lives in Virginia with her husband, Paul, and their two children.

Name: Nina Burkardt
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Name: Hal Cardwell
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Bio: Hal Cardwell is with the Corps of Engineer's Institute for Water Resources, and is presently leading the conceptual development, case studies, and outreach to promote collaborative modeling approaches for water conflict resolution. High on the agenda is the creation of a federal Center for Computer Assisted Dispute Resolution (CADRe). His program is also working to develop and apply these techniques in various basins. Hal also represents the Corps on the National Science and Technology Council's Subcommittee on Water Availability and Quality – an interagency federal groups helping set research directions in water for the federal government.

Prior to coming to the Corps in 2002, Hal was with Oak Ridge National Laboratory's Environmental Sciences Division for a decade, including five years on loan to the US Agency for International Development (USAID). While at Oak Ridge, he provided technical analysis for relicensing of FERC hydropower projects with specific emphasis on balancing environmental and economic uses of water and instream flow issues. At USAID Hal spent three years in Panama working on watershed management and climate change projects for the Panama Canal Watershed and for two years provided global field support to USAID water resources projects in developing countries.

Hal is functionally fluent in Spanish, holds a Ph.D. from Johns Hopkins University and now teaches there part time. He is an active member of the American Society of Civil Engineers' Environment and Water Resource Institute.

Name: Doug Clark
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Bio: I am in the very earliest stages of my exposure to computer-aided dispute resolution. I recently took a class on a software package called "The Visual Interactive Sensitivity Analysis" package. It is a multiple criteria analysis decision support system. I am working my way through this package and through the related literature.

Name: James L. Creighton
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Bio: James L. Creighton, Ph.D., is the President of Creighton & Creighton, Inc. He has been in the public participation/collaborative planning field since 1972. His work in the field includes designing or conducting nearly 300 public participation programs for more than 50 Federal, state and local agencies, public utilities and private sector companies. He has been involved in setting up and facilitating more than 20 advisory committees or task forces. He was the founding President of the International Association for Public Participation, serving two terms. For ten years he served as head of a team of consultants providing support to the Army Corps of Engineers Alternative Dispute Resolution program, a program that received the Hammer Award from Vice President Gore. Creighton is the author of three books on public participation, including **The Public Participation Handbook** (Jossey-Bass, 2005) and is co-author of a text on social impact assessment.

Name: Mike Deering
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Name: Andrew D. Dehoff
Title: Director of Planning and Operations
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Bio: Andrew Dehoff spent ten years as a water resources engineer at SRBC before becoming the Director of Planning and Operations for the Commission. In that time, he was involved in many

aspects of water resources management, including water availability and safe yield analyses, reservoir operations, and drought and flood management. He developed and now oversees the use of several computer models for the purpose of simulating and evaluating water management and use projects throughout the basin.

Mr. Dehoff has also been involved in the Commission's regulatory program, reviewing and making recommendations related to proposed surface water withdrawals, interbasin transfers, and the consumptive use of water by industries and power generation facilities. He now oversees the Commission's effort to plan for long-term mitigation of consumptive water use and its impact on local resources and the Chesapeake Bay.

Mr. Dehoff received his B.S. and M.E. in Civil Engineering from the University of Virginia, and has been a licensed professional engineer since 2001.

Name: Ane D. Deister
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Bio: Ms. Deister currently serves as the General Manager of El Dorado Irrigation District (EID) headquartered in Placerville, California. EID is a full service utility serving approximately 100,000 residents, providing water, wastewater and recycled water services, hydroelectric power generation and recreational opportunities. There are over 300 employees at EID, the service area covers 220 square miles, with elevation ranging from 400 feet to almost 4,000 feet. El Dorado County is part of the area of origin for the water supplies to the California Bay – Delta, which has been the subject of intense stakeholder involvement and regulatory conflicts for several decades.

Deister has over 30 years of experience in the water resources industry, working in executive level appointed positions in Florida and California. In 1978 Deister was confirmed by the California legislature as Assistant Secretary for Resources and in 2003 Deister was confirmed by the California legislature as a member of the California Water Commission. The Resources Agency is an umbrella agency comprised of several departments including Water Resources, Conservation, Forestry, Parks and Recreation, the Coastal Commission, and the Energy Commission, where she served as the agency representative. The California Water Commission is responsible for adopting the rules and regulations governing the California Department of Water Resources water and energy programs among other matters. Additionally Deister was appointed to the Governor's Recycled Water Task Force, created by the California legislature to develop recommendations to expand and enhance recycled water programs throughout the state.

She previously held senior executive positions with the Metropolitan Water District of Southern California in the Office of the General Manager, where she was involved in a number of politically charged conflict resolution activities involving multiple stake-holders centered around water resource management and flood protection disputes. She also developed a state-of-the-art bench marking and organizational efficiency program for a number of functions, significantly reducing the administrative overhead costs at Metropolitan.

In 1995 Ms. Deister was appointed to the President's National Drought Policy Commission, serving as the urban water representative for 5 years. She serves on numerous boards and councils with national organizations, and both state-wide and regional entities in California.

Name: Jerry Delli Priscoli
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Bio: Dr. Delli Priscoli is a world-renowned facilitator of water resources forums. He served as chief facilitator for AWRA's National Water Resources Policy Dialogues, held in Washington, D.C. in 2002 and Tucson, Arizona in 2005. Dr. Delli Priscoli has worked with the World Bank, UNESCO, WHO, and other organizations on multilateral negotiations concerning water resources and worked closely with the Mexican government on the 4th World Water Forum. Dr. Delli Priscoli received his Ph.D. in Political Science from Georgetown University in 1975. He is currently Editor-in-Chief of Water Policy, the official peer-reviewed journal of the World Water Council.

Name: Christopher N. Dunn
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Bio: Christopher Dunn is the Director of the Hydrologic Engineering Center, Institute for Water Resources. The center has a staff of 40 with a $6M annual program for research, software development, technical assistance, special projects, and training/technology transfer. He has previously spent five years as Chief of the Water Resource Systems Division, Hydrologic Engineering Center, IWR. During his time he lead the Division in the development and application of Flood Damage Reduction, Ecosystem Restoration, and System Analysis software. He was also the project manager for the Helmand Valley Water Management Plan for Afghanistan as well as the lead manager for data and modeling project for Iraq. He has also spent about two years as the Senior Hydraulic Engineer, for the Water Resource Systems Division and Planning Analysis Division, Hydrologic Engineering Center, IWR. During his time he worked with the Flood Impact Analysis program and its incorporation into the Corps Water Management System where he integrating the FDA and FIA models. He was also the Project Manager for HEC's role in Sacramento and the San Joaquin Comprehensive Study. Early in his career he spent 13 years as the Regional Hydraulic Engineer for the Federal Highway Administration. During his time he specialized in urban hydrology, urban, highway and bridge hydraulics, stream stability issues and erosion control.

Name: David Eaton
Title: Professor of Natural Resource Policy Studies
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Bio: David J. Eaton received his Ph.D. in environmental engineering and geography from The Johns Hopkins University. Eaton teaches courses on systems analysis, environmental and energy policy, and nonprofit management in the LBJ School. He has lectured in twenty countries and conducted field research in fifteen nations.

Eaton has written on rural water supply, international water resource conflicts, energy management, environmental problems of industries, management of emergency medical services, applications of mathematical programming to resource problems, insurance, and agriculture. His research focuses on sustainable development in international river basins, evaluation of energy and water conservation programs, and prevention of pollution. Among his recent publications are the NAFTA Handbook for Water Resource Managers and Engineers, Emergency Medical Services in Travis County, Texas and The Impacts of Trade Agreements on State Provincial Laws.

Eaton's current research concerns U.S.-Mexico environmental cooperation, new methods for evaluation of air pollution emissions, joint management by Palestinians and Israelis of shared groundwater, and water conservation in Texas. The Texas Department of Insurance used research on tort reform directed by Eaton as evidence to justify rebates of over $1.3 billion for liability insurance in Texas in 1997-1999.

Name: Tony Eberhardt
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Bio: In the early 1990s, I developed a concept for equating stakeholder satisfaction with a particular hydrologic condition such as water levels or flows – a score of zero representing an unacceptable condition, varying to a score of one representing an ideal condition. The resulting "interest satisfaction" curves where developed for the stakeholder groups around Lake Ontario through interviews, questionnaires and experience through the International St. Lawrence River Board of Control, for which I was the U.S. alternate regulation representative. The Fortran/Visual Basic – based IS Model was a contender for replacing the lake Ontario management plan – Plan 1958-D. Through SVP, it evolved into one of the management plan options recommended to the International Joint Commission during the International Lake Ontario-St. Lawrence River Study completed in May 2006. The technique allows stakeholders to view the impact of changing hydrologic conditions on competing interests through sensitivity analyses providing a key component of the shared vision planning framework.

Since most of my experience has been related to the Great Lakes, I'd like to hear about other cases and situations to identify improvements to the techniques developed during the ILOSLR Study. Similar models will likely be used for the recently initiated International Upper Great Lakes Study and might lead to applications in Columbia River work.

Name: Kirk Emerson
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Bio: Kirk Emerson has been the Director of the U.S. Institute for Environmental Conflict Resolution (U.S. Institute) of the Morris K. Udall Foundation since its creation by the U.S. Congress in 1998. The U.S. Institute is charged with assisting the federal government in implementing Section 101 of the National Environmental Policy Act (NEPA) through conflict resolution and collaborative problem solving. The U.S. Institute provides case assistance, training and policy development and focuses on environmental, natural resources, and public lands conflicts where a federal agency or interest is involved. It draws on the expertise of its Tucson, Arizona-based staff and more than 260 pre-qualified ECR professionals around the country.

Dr. Emerson's work has focused primarily on interagency and intergovernmental natural resource conflicts. Most recently, she has been working to implement a federal policy on ECR, develop a handbook on NEPA and Collaboration for the President's Council on Environmental Quality, and evaluate ECR outcomes and performance.

Previously, at the University of Arizona's Udall Center for Studies in Public Policy, Dr. Emerson taught conflict resolution and worked on water resources, endangered species, and western range issues. Dr. Emerson received her B.A. in Psychology from Princeton University, a Masters in City Planning from Massachusetts Institute of Technology, and a Ph.D. in Political Science and Public Policy from Indiana University.

Name: Michael Eng
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Name: Peter Evans
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Bio: Peter Evans is an environmental strategist with 25 years experience as a scientist, an attorney, an agency manager and an advocate of natural resource stewardship. He has been Director of the Interstate Council on Water Policy (ICWP) since May 2005, where his top priorities include building support for the water science and streamgaging programs and for interstate water organizations.

He started his professional career in 1976 evaluating geochemical and geophysical measurements, lab analyses and computer simulations for the USGS and NASA. Attracted to natural resource management tensions, he applied his science background to the regulation and reclamation of mining operations by the Colorado Department of Natural Resources, especially in efforts to help small mining companies comply with new environmental requirements.

Peter practiced law in Colorado for 5 years, counseling municipal and corporate clients on natural resource development projects that required the extensive environmental review and compliance with water quality protection, wildlife management, hazardous waste disposal, mined land reclamation and public disclosure laws. Between 1990 and 2000, he served as Legal Counsel to the Executive Director of the Colorado Department of Natural Resources and as Director of the Colorado Water Conservation Board, leading its development of state water policy, promulgation of rules and oversight of integrated water resource development, flood protection and environmental protection programs. He represented the state of Colorado in federal and interstate commissions responsible for wildlife and water resource management.

He holds a BA in Geology from Pomona College (Claremont, CA, 1976) and a JD from the University of Denver (Denver, CO, 1985).

Name: Michael Fies
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Bio: Michael Fies is currently the Project Manager of the Upper Rio Grande Water Operations Model effort for the Albuquerque District. Prior to joining the District in March 2007, Mr. Fies served as Project Manager and Technical Lead of the large aquifer, storage, and recovery program, a key component of the Florida Everglades restoration project. He has over twenty-two years experience in the private and public sector and has been recognized as an expert in Hydrogeology by the Corps of Engineers. Mr. Fies' experience encompasses a wide variety of water resource, environmental, and civil works projects, primarily in the western and southwestern U.S. and the Republic of Ireland. Mr. Fies's technical expertise is in the development of water resources in complex geologic settings, particularly in fractured bedrock and karst environments. Mr. Fies has authored several technical articles and is a licensed Professional Geologist in Arizona and Idaho. He obtained his B.A. in Geology from California State University, Chico and his M.S. in Geology from Oklahoma State University.

Name: Erik Hagen
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Name: Jordan Henk
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Bio: Mr. Henk directs operations and research at the Redlands Institute. He sets policy and ensures that RI effectively implements its Strategic and Business plans. Mr. Henk manages staff and personnel administration. He coordinates business development and professional development to grow RI's expertise and research experience.

Name: Carly Jerla
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Bio: Carly Jerla has worked for the Lower Colorado Region of the Bureau of Reclamation (Reclamation) as a hydraulic engineer since 2005. Prior to joining Reclamation, she was a graduate student at the University of Colorado where she worked as a research assistant at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES), a research center jointly sponsored by Reclamation, the Tennessee Valley Authority and the U.S. Army Corps of Engineers. At CADSWES she gained valuable experience in the river basin modeling tool RiverWare by providing user support for model building and model debugging, coding engineering algorithms in the RiverWare software and teaching training classes. As part of her M.S. thesis, Carly developed CRSS-Lite, a simplified yet verified version Reclamation's official long-term planning model CRSS, geared for stakeholder use. As a Reclamation employee, Carly is stationed at CADSWES and has been directly involved with the hydrologic modeling for the EIS to develop guidelines for the next twenty years for the operation of Lake Powell and Lake Mead. Carly received a M.S. in Civil Engineering from the University of Colorado in 2005 and a B.S. in both Civil Engineering and Engineering and Public Policy from Carnegie Mellon University in 2002.

Name: Rich Juricich
Title: Senior Engineer, Water Resources
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Bio: Rich Juricich is a Supervising Water Resources Engineer with the California Department of Water Resources. He is part of the California Water Plan Update team and is project manager for efforts to improve the analytical approach for Water Plan Update 2009. He has worked at

DWR for over 12 years, which has included assignments working on the initial CALSIM development and working with local agencies to develop conjunctive management programs. Rich has a Master of Science Degree from the University of California, Davis in Hydrologic Sciences, and he has a Bachelor of Science Degree from Humboldt State University in Environmental Resources Engineering. He is registered as a Professional Civil Engineer in State of California.

Name: Herman Karl
Title: Co-Director, MIT-USGS Science Impact Collaborative (MUSIC)
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Bio: Herman A. Karl has been co-director of the MIT-USGS Science Impact Collaborative (MUSIC) since 2004. Dr. Karl, a USGS scientist, holds a faculty appointment as a Visiting Lecturer in the Department of Urban Studies and Planning at the Massachusetts Institute of Technology. Dr. Karl began his career with the U.S. Geological Survey in 1977 as a National Research Council Research Associate in marine geology. He has been chief scientist of numerous research cruises and of several major projects. Prior to becoming co-director of MUSIC he was Chief Scientist of the Western Geographic Science Center. Karl has been a visiting scientist at the Institute of Oceanographic Sciences, United Kingdom and a Senior Associate with the Harvard Law School Program on Negotiation. He has authored/co-authored about two hundred articles, abstracts, book chapters, maps, and reports and has given numerous invited presentations. One of his research interests is exploring the development and use of models with multi-stakeholder groups as part of a collaborative process. Dr. Karl received a Ph.D. from the University of Southern California in Geological Sciences, a M.S. from the University of Nebraska in Geology, and a B.S. from Colgate University.

Name: Tim Karpoff
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Name: Paul Kirshen
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Bio: I have been using many types of computer models for decades to work with stakeholders to address complex water resources operational and planning issues. These have often been in the context of IWRM. I have not used such tools directly in dispute resolution and hope to learn about this at the workshop.

Name: Beaudry E. Kock
Title: Urban Studies and Planning
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Bio: Beaudry Kock is an MIT doctoral student based in Cambridge MA, working within the MIT-USGS Science Impact Collaborative (MUSIC). MUSIC is an action research group engaged in the analysis and support of complex stakeholder-oriented environmental decision making. His research focuses on agent-based modeling of social-hydrologic systems in the western US, and he is currently involved in modeling and stakeholder-engagement projects in southern Colorado and eastern Idaho. His experience with Computer Aided Dispute Resolution stems mainly from this work, which is attempting to develop a collaborative process for constructing large agent-based simulation tools in partnership with local stakeholders.

Name: Stacy Langsdale
Title: NRC Post-doctoral Fellow
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Bio: Dr. Langsdale completed her Ph.D. in Resource Management Environmental Studies from the University of British Columbia in spring 2007. For her dissertation she designed and led a group model building exercise to explore water management and climate change futures in the Okanagan Basin in British Columbia. Stacy also has a Masters in Hydrology from the University of Nevada, Reno, and a Bachelors of Science in Civil Engineering from the University of Maryland.

Stacy started working with the Institute for Water Resources in June to critically evaluate collaborative modeling tools and processes and to promote use of this methodology by applying it in new case studies, developing documentation, and building the CADRe community.

Name: Mark Lorie
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Bio: My experience with Computer Aided Dispute Resolution began with my work on the Lake Ontario St Lawrence River Study while working for the Institute for Water Resources. We used the Shared Vision Planning approach to work with stakeholders while developing new plans for managing lake levels and outflows in a ways that better balance economic and environmental objectives. I helped develop the Computer Aided Dispute Resolution Program at the Institute for

Water Resources. My work on the program included research on the application of SVP to regulatory issues, project development in several Corps Disctricts, and outreach. Now with the Interstate Commission on the Potomac River Basin, I am playing a lead role in Shared Vision Planning study to re-evaluate reservoir operations and how those operations affect water quality, water supply, fisheries, and recreation.

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Bio: Jay R. Lund is a Professor of Civil and Environmental Engineering at the University of California, Davis. He served on Advisory Committees for the 1998 and 2005 California Water Plans, as Convenor of the California Water and Environment Modeling Forum, and Editor of the *Journal of Water Resources Planning and Management*. He is a member of the International Water Academy and has won several awards for water-related research and service from the American Society of Civil Engineers. He is the principal developer of the CALVIN economic-engineering optimization model of California's inter-tied water supply system, applied regionally and statewide to explore water markets, conjunctive use, integrated water management, climate change, and environmental restoration. He has had a major role in water and environmental system modeling projects in California, the United States, and overseas. His principal specialties are simulation, optimization, and management of large-scale water and environmental systems, the application of economic ideas and methods, reservoir operation theory, and water demand theory and methods. He is author or co-author of over 200 publications and obviously has a short attention span. He has been involved in "shared vision" modeling in the southeast and California.

Name: Diane McNabb
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Name: Richard Miles
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Bio: Richard Miles serves as the Federal Energy Regulatory Commission's Director of Office of Administrative Litigation (OAL)(2006 – present), Director of Dispute Resolution Service (DRS)(1999 – present), and Dispute Resolution Specialist. Prior assignments at the Commission include: Associate General Counsel for Administrative Litigation; Assistant General Counsel for Electric and Corporate; Supervisory Trial Attorney (1984 – 1986); and, Trial Attorney representing the public (1973 – 1984). In 1987, he was selected to be a member of the federal government's Senior Executive Service

As Director of OAL, he is responsible for trial staff's participation in oil, gas, and electric cases set for hearing. The 80+ lawyers and expert witnesses in this Office represent the public interest and seek to litigate or settle cases in a timely, efficient and equitable manner while ensuring the outcomes are consistent with Commission policy and precedent.

As Director of the Dispute Resolution Service, he performs numerous alternative dispute resolution (ADR) functions, including acting as a facilitator and mediator in oil, gas, electric, pipeline, tribal, and hydroelectric cases. He also supervises ADR specialists. Rick has received training in ADR from a number of sources, such as the introductory and advanced mediation courses and the negotiation course taught at Harvard's Program of Instruction for Lawyers, and Harvard's "Teaching Negotiation in the Organization" course.

Rick appears on ADR panels and conducts workshops and training in negotiation and mediation. Examples of Rick's efforts have included presentations at American Bar Association's and Energy Bar Association's functions, the Foreign Service Institute's Training Center, Canada's National Energy Board, the California Public Utility Commission, the Regulatory Commission of Alaska, the South Asia Regional Regulators meeting, the China Electricity Council, and other state, national, and foreign organizations.

In April 2005, Rick ended his term as chair of the federal government's Interagency Alternative Dispute Resolution Group Steering Committee. He is also currently chair of one of the federal government's the Civil Enforcement and Regulatory Section ADR Working Group. Additionally, Rick was a leader and contributor to the "Report for the President on the Use and Results of Alternative Dispute Resolution in the Executive Branch of the Federal Government," submitted to the President in April 2007. He can be reached at (202) 502-8702 or by email at richard.miles@ferc.gov.

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Name: Richard Palmer
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Bio: Richard Palmer is a Professor of Civil and Environmental Engineering at the University of Washington, where he has taught since 1979. His primary areas of interest are in the application of structured planning approaches to water resources. This includes impacts of climate change on water resources, drought planning, real-time water resource management, and the application of decision support to civil engineering management problems. He helped develop the field of "shared vision modeling" in water resources planning and pioneered the use of "virtual drought exercises."

Dr. Palmer received his Ph.D. from the Johns Hopkins University in 1979, his Master's of Science in Environmental Engineering from Stanford University in 1973. He received the "Service to the Profession" Award from the Water Resources Planning and Management Division of American Society of Civil Engineers (ASCE) in 1998. He was awarded the "Certificate of Recognition" for his editorial services to the *Journal of Water Resources Planning and Management* of ASCE in 1997, for which he was editor from 1993-1997. He was awarded the Huber Award for Research Excellence by the American Society of Civil Engineers (ASCE) in 1992. This honor was based upon his innovative application of simulation and optimization techniques to issues in water resource management. He received recognition for the Best Practice-Oriented Paper of the Year in the Journal of Water Resources Planning and Management by the ASCE in 1989. During his Ph.D. research he was a member of a team at Johns Hopkins University and the Interstate Commission on the Potomac River Basin recognized as a finalist by ASCE for Engineering Achievement of the Year in 1983. In 2006, he received from ASCE the Julian Hinds Award for his contributions to water resources planning and his research related to the impacts of climate change on water resources.

Name: Chandler Peter
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Bio: : U.S. Army Corps of Engineers, Omaha District, Wyoming Regulatory Office, Regulatory Project Manager. More than 20 years experience in Federal and state government in aquatic resource regulation. Currently responsible for directing Section 404 Permitting and NEPA analysis of several major water supply and infrastructure development activities in the Rocky Mountain and Great Plains regions. Testing the ability to incorporate CADRe processes with the Corps' Regulatory Permit Program for two major water supply actions involving ecosystem restoration in the Cache la Poudre River basin.

Name: Tarla Rai Peterson
Title: Professor & Boone and Crockett Chair
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Bio: Dr. Peterson's research focuses on the intersections between communication, environmental policy, and democracy. She is author/editor of Communication and the Culture of Technology (1990, Washington State University Press), Sharing the Earth: The Rhetoric of Sustainable Development (1997, University of South Carolina Press), Green Talk in the White House: The Rhetorical Presidency Encounters Ecology (2004, Texas A&M University Press), Argumentation and Critical Decision Making (2004, Allyn and Bacon).

Name: Suzanne Pierce
Title: Senior Member of Technical Staff
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Bio: Suzanne Pierce is a Senior Member of Technical Staff in the Systems Dynamics and Decision Support Research Group of the Geohydrology Department for the Energy, Resources, and Systems Analysis Division at Sandia National Laboratories.
She has a background in environmental resource management, with a specialization in water resources management and hydrogeology. Dr. Pierce received a B.S. in Geology from the University of Arkansas and completed doctoral studies at the Jackson School of Geosciences at The University of Texas in Austin. A Science To Achieve Results (STAR) fellow for the Environmental Protection Agency and Scholar of the Philanthropic Educational Organization (P.E.O), Dr. Pierce's work to date has garnered recognition at the local, regional, national, and international levels.

Her interests in science-based decision support for resource management began while she was the Environmental Manager for the El Abra Copper Mine in the Atacama Desert of Chile. The flagship property was the seventh largest copper mine in the world and first U.S.-Chile joint venture in Chile in more than two decades. Dr. Pierce designed and implemented international level compliance plans, acted as the company liaison between local groups, national agencies, and international interests through construction, production start-up, and normal operation phases for the mine site.

Today, Dr. Pierce's research builds upon earlier experiences in environmental management, through the construction of a dynamic decision support system that presents methods for linking spatially explicit groundwater models with combinatorial optimization techniques and social preference sets to identify and evaluate science-based water resource management policies. The resultant decision support system is currently in use for drought policy determination by the Barton Springs Groundwater Conservation District (Austin, TX) and subsequent versions are supporting real-world regional groundwater management planning efforts in central Texas.

Name: Stan Ponce
Title: Acting Regional Executive for Biology, Central Region
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Bio: Dr. Stanley Ponce has been a Federal land and water resource manager for nearly 30 years. He has been widely recognized for his innovative leadership style, strategic vision, and ability to develop programs, establish partnerships, and motive people.

Currently, Stan is serving as the Acting Regional Biologist and is responsible for the overall management and direction of the biology program within the Central Region of the USGS, including oversight of five biology Science Centers. Before joining the Regional team, he provided executive leadership in developing the policy framework for the USGS' Fundamental Science Practices and represented the Survey on the Interagency Cooperative Conservation Team within DOI.

During his career Stan has served as a Senior Advisor to the Assistant Secretaries of Water and Science and Fish, Wildlife and Parks within the Department of the Interior; Research Director for the Bureau of Reclamation; Chief of the Water Resources Division for the National Park Service; Associate Regional Director for Resources (Natural and Cultural) in the Rocky Mountain Region of the National Park Service; Director of the Watershed Systems Development Group with the U.S. Forest Service; and an Associate Professor of Earth Resources at Colorado State University. He has extensive experience in developing national water resources policy, managing complex scientific and engineering programs, and building coalitions.

He received his Ph. D. in Civil and Environmental Engineering from Utah State University, M.S. in Watershed Science and Forest Engineering from Oregon State University, and B.S. in Forestry and Natural Resources from the University of Missouri.

He is also a registered Professional Hydrologist and has received the Department of the Interior's Meritorious Service Award.

Name: David R. Purkey
Title: Director
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Bio: I am the Director of the Water Resources Group of the Stockholm Environment Institute-US Center. In this capacity, I am responsible for all hydrological assessment and modeling work conducted by the Institute. Much of this work involves the development of data management systems, including GIS databases, and the application of water resources models to explore the implications of future management scenarios regarding the use, conservation and protection of water resources. The Water Evaluation and Planning (WEAP) system developed by SEI-US is central to much of this work. My career has evolved from an early focus on irrigation engineering to a broader focus on the hydrology of irrigated catchments, to my current focus on integrated water management at a variety of scales. The question of the potential impact of climate change on water management, and appropriated management adaptations is an increasing

focus of our research at SEI-US. My areas of technical expertise include surface water hydrology, hydrogeology, and water resources systems analysis. My career has been fairly evenly divided between activity in the western United States and the developing world. I received an M.S. and Ph.D. from the University of California, Davis and a B.A. from Carleton College.

Name: Jesse Roach
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Bio: Jesse Roach finished Bachelor of Science degrees from Stanford University in Biology and Civil Engineering in 1995, and a Masters of Science degree, also from Stanford, in Civil and Environmental Engineering in 1997. Jesse received his PhD in Hydrology from the University of Arizona in 2007. His doctoral thesis titled "Integrated surface water groundwater modeling in the Upper Rio Grande in support of scenario analysis" documents the development of a basin scale socio-hydrologic model designed for rapid evaluation of water use scenarios in the Rio Grande basin in New Mexico.

Name: Marissa D. Reno
Title: Hydrologist
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Bio: Marissa D. Reno is a hydrologist with a strong interest in sustainable resource management and developing effective tools to support decision making bodies and individuals, including the development of system dynamics models. Marissa joined Sandia National Laboratories' Geohydrology Department as a technical undergraduate student intern in 2003, at which time she was pursuing degrees in Economics and Environmental Science (B.A., B.S., 2004) at the University of New Mexico. She recently earned a M.S. in Hydrology (2007) from the New Mexico Institute of Mining and Technology and continues to be fascinated by water in all its states, processes, and uses, and eagerly engages in opportunities that address the complex sociotechnological challenges surrounding water.

Marissa's first experience with CADRe came in 2002 when she worked with David Brookshire's research group (University of New Mexico Department of Economics) and had a primary role in organizing and conducting economic valuation experiments dealing with water usage and allocation in the Middle Rio Grande Basin; this paper-based experiment was later converted into a web-based one. In 2005, Marissa joined Sandia's System Dynamics (SD) modeling team, led by Vince Tidwell, and began supporting the development of water-centric dynamic simulation models built in Powersim. As a part of this team, Marissa has acted as a project lead in creating a SD model for water-energy-food resource assessment in Iraq. She was also a primary contributor in the development of an SD-modeling training program whose ultimate goal was to provide an effective tool to aid in the sustainable and peaceful management of natural resources worldwide and was administered in Amman, Jordan in 2005 and included participants from Iraq, Turkey, Syria, Jordan, and countries of the Aral Sea Basin.

Name: Beth Richards
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Bio: Beth has interests in both water and energy sustainability. She has more than twenty years of experience in the energy field, focused mostly on solar and other renewable energy technologies at Sandia National Laboratories in Albuquerque, New Mexico, and Winrock International, a non-profit development organization, in Washington, D.C. Her career has included research & development, evaluation, commercialization, and application of new technologies, as well as project management, program development, and strategic planning.

Beth is currently completing a Ph.D. in the Interdisciplinary Graduate Program in Environment and Resources (IPER) at Stanford University. Her research is focused on water allocation and reallocation processes in the western U.S., involving concepts and theory from law & institutions, political economy, economics, and hydrology. Specifically, she is investigating the emergence in New Mexico of water rights settlement agreements as a mechanism for resolving longstanding conflicts over water. Beth also has B.S. and M.S. degrees in mechanical engineering from Iowa State University and the University of Michigan.

Beth has only recently become involved with collaborative modeling (although she has experience with other types of modeling in a past life). Her interest in collaborative modeling (and the CADRe workshop) was prompted by its ability to link different disciplines and capture the interdependencies of different aspects of a problem, its predictive power for exploring possible intended and unintended consequences of various options, and its potential for getting people with differing value systems to at least agree on the facts of a situation, thus breaking through difficult impasses and moving toward problem solving.

Name: James “Ric” Richardson
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Bio: Ric Richardson, Professor, was formerly Dean and Associate Dean of the School of Architecture and Planning. Ric received an M Arch in Advanced Studies and Master of City Planning from MIT, while his B Arch is from the University of Colorado-Boulder. Ric recently completed a major project mediating negotiations among ranchers, oil and gas executives, federal and state agencies, and local citizens to prepare a consensus-based conservation strategy for a bird species in Southeastern New Mexico. The negotiated agreement is a first of its kind to avoid listing a species as endangered. He is a senior Associate at the Consensus Building

Institute, Cambridge, MA, the MIT-Harvard Public Disputes Program at the Harvard Law School, and The Lincoln Institute for Land Policy.

Name: Dan Rodrigo
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Bio: Mr. Rodrigo is a senior water resources planner with CDM with over 18 years experience. He has a BS degree in geography and economics, and a MS degree in environmental planning, both from Southern Illinois University. Mr. Rodrigo has expertise in integrated resources planning, decision support systems, stakeholder facilitation and conflict resolution, resources economics and designing public processes for maximizing stakeholder involvement.

Over the last 10 years, Mr. Rodrigo has used decision support systems in collaborative stakeholder-driven planning for over a dozen projects in California and the Western United States. Some of his recent experience includes developing system models and integrated water management plans for the Metropolitan Water District of Southern California, City of San Diego, City of Los Angeles, Santa Clara Valley Water District, City of Santa Fe, and the State of Colorado. In all of these cases, the resulting water plans had a high degree of stakeholder support and are now in the project implementation phase. And in fact, many of these plans resulted in mutually successful resolution of prior lawsuits and stalemates.

Name: Leonard Shabman
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Bio: Leonard Shabman has served as a staff economist at the United States Water Resources Council (October 1977-October 1978), as Scientific Advisor to the Assistant Secretary of Army, Civil Works August (1984- 1985) and as Visiting Scholar at the National Academy of Sciences National Research Council (2001). From 2004- 2006 he served as the Arthur Maass-Gilbert White Scholar at the Corps Institute for Water Resources at Fort Belvoir, VA. He presently is Resident Scholar at Resources for the Future and is professor emeritus at Virginia Tech where he was on the faculty for 30 years, and for 7 years served as the Director of the Virginia Water Resources Research Center. He is currently a member of the National Academy of Sciences, National Research Council, Water Science and Technology Board. He has served on several Academies Committees and provided consultation and advice on water policy and management to a diversity of governmental and non-governmental organizations.

Name: A. Michael S. Sheer
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Bio: A. Michael S. Sheer, Environmental Scientist. Graduating from the Uiversity of Maryland in 2005, Mr. Sheer has been involved in several ongoing modeling projects across a variety of systems with HydroLogics, Inc. Although his degrees in agriculture and biology trend him towards more performance measure oriented work, he has helped build, modify, and run OASIS models for nearly two years. His primary role, however, has been in the construction and refinement of biological and hydrologic performance measure. In this regard, he specializes in converting generalized performance ideals to useful metrics.

Name: Daniel P. Sheer
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Bio: Dr. Sheer has over 32 years of experience in integrated management of reservoir systems, systems operations, modeling water supply operations, especially using optimization based simulation models. He has been a pioneer in the field of computer-aided conflict resolution, and has used computer aided dispute resolution to assist in the development of the Cooperative Operations Section of the Potomac River Commission, the Las Vegas Valley Water Authority, the Kansas River Water Assurance District, and in a wide variety of other disputes in the U.S. and abroad. Dr. Sheer is a co-developer of OASIS, a multi-objective optimization based simulation package designed to support computer aided disputer resolution in water resources. OASIS is used to help manage river basins and water supply systems that serve a substantial portion of the U.S. population.

Dr. Sheer earned a Ph.D. with Distinction, Environmental Engineering in 1974 from the Johns Hopkins University in Baltimore, Maryland and has a B.S. in Natural Sciences, 1971, from the same institution. He is a Professional Engineer, State of Maryland. Among other honors, he was a founding member of the National Research Council Water Science and Technology Board.

Name: Kurt Stephenson
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Bio: Kurt Stephenson joined the faculty of Virginia Tech in the fall of 1995. Kurt's research interests include water resource policy, the role technical analysis in environmental policy, and the use of economic incentives in environmental policy. He has served on numerous advisory committees regarding water quality and effluent trading policy issues. Stephenson just recently completed a six-month sabbatical leave with the Institute for Water Resources.

Name: Diane E. Tate
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Bio: Diane Tate is a Program Manager at CDR Associates, an internationally recognized organization of conflict resolution specialists headquartered in Boulder, Colorado. She brings both engineering and international diplomacy expertise to her work facilitating decision-making over complex public policy issues, most centering on the management and use of water resources. Prior to joining CDR, Ms. Tate served as a water policy advisor to the U.S. Department of State. In this role, she developed partnerships and initiatives to advance access to water and sanitation in developing countries and mitigate conflict over transboundary water resources. Her responsibilities included extensive coordination with the U.S. Agency for International Development (USAID) and other federal agencies. Ms. Tate joined the Department of State through the Presidential Management Fellows program, and received a Superior Honor Award for her work developing a program to support integrated water resource management in developing countries.

Ms. Tate was awarded her Masters in Public Affairs from the University of Texas at Austin's Lyndon B. Johnson School, and received mediation training from the University of Texas School of Law. During her graduate career, Ms. Tate designed and programmed a surface water resources model of the lower Rio Grande/Rio Bravo basin, and developed strategies for building collaborative relationships between Texan and Mexican government officials during a multi-party operations simulation. Her master's report reflects this work and additional research on the role of technology in mediation. Prior to her graduate work, Ms. Tate designed and managed water, sanitation, and drainage systems for municipalities in the State of Texas as a licensed professional civil engineer. She graduated from Rice University with a B.S. in Civil Engineering. Ms. Tate serves as a member of the Governing Board for the non-profit Engineers Without Borders-USA.

Name: Jessica Leigh Thompson
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Bio: My area of expertise is environmental communication and conflict resolution. Recently, I have worked with an interdisciplinary team of scientists and community stakeholders to build a system dynamics model of issues related to an urban airshed. I have also used collaborative computer model building to better understand and explain conflicts and communication dynamics among the scientists working to address complex environmental problems. I hope to learn how other contexts, situations, and software applications have facilitated effective dispute resolution about natural resources.

Name: Vince Tidwell
Title: Principle Member of the Technical Staff
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Bio: Dr. Tidwell holds a Masters Degree from the University of Arizona (1988) and a Ph.D. from New Mexico Institute of Mining and Technology (1999) in the field of hydrology. He worked as a consulting environmental engineer for Roy F. Weston, Inc. from 1988-1990. In 1990 Dr. Tidwell was employed by Sandia National Laboratories in Albuquerque, NM and currently holds the position of Principle Member of the Technical Staff.

Dr. Tidwell has 18 years experience conducting and managing research on basic and applied projects in water resource management, nuclear and hazardous waste storage/remediation, and petroleum recovery. His areas of expertise include resource management modeling, community-based decision analysis, water monitoring, surface water hydrology, field and laboratory experimentation, and stochastic methods.

Dr. Tidwell is working to establish a multi-agency, multi-university center devoted to the creation and application of computer-aided decision support tools and stakeholder mediated decision processes. Focus of this effort is on water resource management and planning. Current projects include water availability studies on the Upper Rio Grande, development of a thermal credit market in the Willamette Basin, water utilization study in the Gila River Basin in southwestern New Mexico, development of groundwater safe-yield limits on the Barton Springs Aquifer near Austin, Texas, and development of water quality management standards for the Zarqa Basin in Jordan. These models adopt a system dynamics framework for integrating the broad physical and social processes important to water planning. Additionally, these system level models are directly linked to a variety of other tools, providing an integrated basis for analysis, visualization and decision support.

Name: Alexey Voinv
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Bio: Dr. Voinov is completing a one-year appointment at IWR where he was working with Gene Stakhiv and Hal Cardwell on participatory modeling. Previously, he was affiliated with the Gund Institute for Ecological Economics and the Computer Sciences Department. Alexey's background is in applied mathematics and computer sciences. He is interested in transdisciplinary research in environmental and sustainability science. Most of his research is in ecosystem modeling, including spatial, dynamic modeling of watersheds, lakes, ponds, etc. His more recent studies are in applied participatory modeling that includes stakeholders in the modeling process to design better management practices and support decision-making.

Name: Erik Webb
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Bio: Webb joined Sandia National Laboratories in 1992, spent two years on a leave of absence working for the Japan Nuclear Cycle Development Institute, and for four years was the manager of the Geohydrology Department. In March 2003, he accepted an assignment to work for the Senate Energy and Natural Resources Committee as a Congressional Fellow, and is currently a Congressional Detailee assigned to the Office of Senator Domenici of New Mexico. Prior to SNL, Webb worked for Union Oil, the US Geological Service, and Oak Ridge Associated Universities. Webb has a BS in Engineering Geology from Brigham Young University, a MS and PhD from the University of Wisconsin in Geology with emphasis on hydrogeological modeling

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Name: William J. Werick
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Bio: Mr. Werick worked for the Corps of Engineers from 1968 until his retirement in April 2004. During that time he worked as a surveyor, dredging specialist and planner for the Buffalo district, on special dredging assignments throughout the U.S., and for the last fourteen years of his Corps career, as a senior planner at the Corps' Institute for Water Resources near Washington, D.C. He has spoken on water resources at Yale, Harvard, Johns Hopkins, Cornell, the University of Washington, the World Bank, United Nations, and the National Academy of Sciences. He has provided expert opinion on water management to the White House Council on Environmental Quality and Congressional subcommittee staff interested in water issues, and has been interviewed on a variety of radio talk shows about water issues. He currently serves as Chairman of the Board of Directors of the Great Lakes Observing System.

Mr. Werick is an expert on drought management. He was one of the principal analysts for the National Drought Policy Commission (1999-2000), and led the National Drought Study for the Corps from 1989 to 1993. During that study, he and Rick Palmer (University of Washington) developed *Shared Vision Planning*. He recently completed a shared vision planning effort by Canada and the U.S. to find better ways to manage Lake Ontario levels. Mr. Werick has applied these methods internationally. He demonstrated the shared vision planning approach for the Middle East Peace process negotiations in Washington in September 1993, and was the U.S. representative to a water loss reduction conference held in Netanya, Israel in 1996 as part of the multilateral peace talks. In the late 1990s he led a panel reviewing the water demands of Newport News, Virginia as part of a Corps Clean Water Act permitting process, part of ongoing work at IWR related to water supply permitting that Mr. Werick continues to participates in.

Mr. Werick holds degrees in mathematics from Canisius College and civil engineering from the State University of New York at Buffalo, He is a registered engineer in New York State, and is a graduate of the Corps Planning Associates program. He currently lives in Culpeper, Virginia with his wife Patty, and several horses, dogs and cats. He is in a multi-decade process of writing a novel: Don't Say Apalachicola-Chattahoochee-Flint, Alabama-Coosa-Tallapoosa.

Name: Megan Wiley Rivera
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Bio: I have been working with HydroLogics, Inc. for two years. Computer Aided Negotiations is one of our specialties. I have focused on two projects in particular: the Apalachicola-Chattahoochee-Flint River, which involves negotiations/litigation between numerous stakeholders in Georgia, Alabama, and Florida; and the Kissimmee River Restoration Project, which involves a "computer-aided participation" process to invite a range of stakeholders and the public at large to contribute and test ideas using a model of the basin. At the conference, I hope to be inspired by other success stories, pick up practical tips that can be applied in our work, and develop ideas for opportunities to work with others of like-vision.