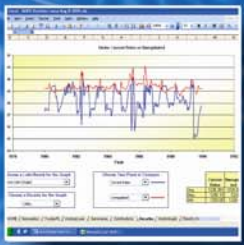
Shared Vision Planning

December 2007

Computer Aided Dispute Resolution:

Proceedings from the CADRe Workshop
Albuquerque, New Mexico
September 13-14, 2007

2007-R-06



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Shared Vision Planning

The Shared Vision Planning program at the Institute for Water Resources (IWR) uses an innovative, collaborative approach to solve water resources management issues. It integrates traditional water resources planning methods, structured public participation, and collaborative computer modeling into a multifaceted planning process. This program is unique because it emphasizes public involvement in water resources management and the use of collectively developed computer models along with tried-and-true Corps planning principles.

Shared Vision Planning aims to improve the economic, environmental and social outcomes of water management decisions. By involving stakeholders throughout the planning process, the Shared Vision Planning process can facilitate a common understanding of a natural resource system and help stakeholders reach a management consensus that satisfies multiple interests. Shared Vision Planning allows IWR scientists to work directly with stakeholders to find acceptable solutions to issues surrounding the management of water resources.

Collaborating for Improved Water Resources Management

Through its Shared Vision Planning Program, IWR is applying the principles of public involvement and collaborative computer modeling to a series of water resources management case studies across the United States. Analyses, documents, and an enhanced web presence are being developed to impart the method and lessons of Shared Vision Planning to the wider planning community. All of these initiatives are designed to help planners and stakeholders use a collaborative approach to natural resources management.

By recognizing the importance of multiple stakeholder interests and the value of innovative technological support, Shared Vision Planning can make a positive impact on the current and future management of our nation's water resources. The Shared Vision Planning Program at IWR is developing partnerships with other organizations to more effectively implement this approach. The Program has already helped numerous stakeholders in previous projects to find acceptable water management solutions, and IWR looks forward to the continued spread and success of this planning approach.

For further information on the Shared Vision Planning program, please contact Hal Cardwell, 703-428-9071, Hal.E.Cardwell@usace.army.mil.

To learn more, please visit the Shared Vision Planning web site: www.svp.iwr.usace.army.mil

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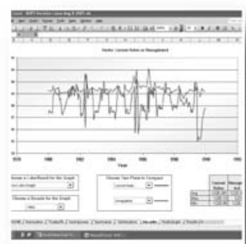

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Preface and Acknowledgements

Computer Aided Dispute Resolution (CADRe) describes the use of computers in a participatory manner to address complex issues and has evolved in different ways by the three agencies that sponsored the workshop. The U.S. Institute for Environmental Conflict Resolution (ECR) was established as a center for expertise in conflict resolution with multiple parties involved in environmental issues. ECR is now exploring and encouraging the use of collaborative modeling as a mechanism for managing the technical data for complex problems within the negotiation setting. Sandia National Laboratories has completed a number of successful projects in which they collaboratively developed system dynamics models with stakeholders for the purposes of increasing understanding and improving management in a watershed. Meanwhile, the Institute for Water Resources developed an approach named *Shared Vision Planning* after conducting "Drought Preparedness Studies" in the early 1990s. Shared Vision Planning specifically relates to the intersection of Corps planning for water management, stakeholder-based processes, and collaborative computer modeling. For the most part, these very similar approaches, as well as others, developed independently. Recent agency partnerships enabled us to learn from one another and to share skills and resources, but this event provided the opportunity to do so as a larger community. It was the first gathering of so many CADRe practitioners and clients. Fifty-two people gathered to foster community, share experiences, identify challenges, and formulate a vision for the field.

The planning team for the workshop included, in alphabetical order:
Hal Cardwell, Institute for Water Resources
Michael Eng, U.S. Institute for Environmental Conflict Resolution
Kirk Emerson, U.S. Institute for Environmental Conflict Resolution
Stacy Langsdale, Institute for Water Resources
Leonard Shabman, Resources for the Future and Institute for Water Resources
Kurt Stephenson, Virginia Tech
Vince Tidwell, Sandia National Labs

Kelly Barnes, Institute for Water Resources, provided organizational support and Diane McNabb, Sandia National Labs, provided on-site administrative help.

The workshop attendees were: Steve Ashby, Allyson Beall, Lisa Bourget, Nina Burkhardt, Hal Cardwell, Douglas Clark, Jim Creighton, Andrew Dehoff, Ane Deister, Jerry Delli-Priscoli, Chris Dunn, Tony Eberhardt, Kirk Emerson, Mike Eng, Michael Fies, Erik Hagen, Jordan Henk, Carly Jerla, Rich Juricich, Herman Karl, Paul Kirshen, Beaudry Kock, Stacy Langsdale, Mark Lorie, Thomas Lowry, Jay Lund, Diane McNabb, Richard Miles, Carl Moore, Richard Palmer, Chandler Peter, Tarla Rai Peterson, Suzanne Pierce, Bob Pietrowsky, Stan Ponce, David Purkey, Marissa Reno, James "Ric" Richardson, Jesse Roach, Dan Rodrigo, Gerald Sehlke, Len Shabman, A. Michael Sheer, Dan Sheer, Kurt Stephenson, Diane Tate, Jessica Thompson, Vince Tidwell, Alexey Voinov, Erik Webb, Bill Werick, and Megan Wiley Rivera.

Computer Aided Dispute Resolution: Proceedings from the CADRe Workshop

Front Matter and Preface

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Executive Summary of the Albuquerque CADRe Workshop

Hal Cardwell
Institute for Water Resources

On September 13th and 14th 2007, in Albuquerque New Mexico, the U.S. Army Corps of Engineers, Sandia National Laboratories and the U.S. Institute for Environmental Conflict Resolution held the first-ever workshop on Computer Aided Dispute Resolution (CADRe). Fifty-three people from six federal agencies, three national laboratories, irrigation districts, state government, river basin commissions, universities, nonprofits and the private sector came together to share experiences as practitioners and promoters of CADRe for water resource planning and management. This was the first gathering of its kind, the focus being exclusively on CADRe, defining its boundaries, best practices; and how to institutionalize and promote CADRe water resources planning and management.

This proceedings document is an attempt to capture the discussions at the CADRe workshop and to summarize the specific action plans defined by those who participated in this event. We also include some relevant additional materials collected after the workshop.

Background and introduction

Persistent conflict among competing stakeholders and decision makers is increasingly common in water resources management. Too frequently, conflicts develop that are beyond the control of individual water management agencies. These conflicts often in result in gridlock over major water resource decisions and their implementation, or a protracted, litigious decision-process that takes years, costs significant sums of money, and fails to generate broad consensus on an acceptable solution. These conflicts occur because of both the complexity and uncertainty in the natural systems (disagreement over the facts) and the conflicting interests and values across individuals and groups.

Within the U.S. Army Corps of Engineers, the Institute for Water Resources (IWR) responded to this situation by developing and promoting ideas of using collaboratively-built computer models to build trust and mutual understanding among stakeholders in water resources planning cases. By engaging stakeholders and decision makers in considering a wider set of complex interactions this “Shared Vision Planning” approach promotes more implementable water management decisions. The value of a process that makes technical modeling the vehicle for engaging stakeholders and decision makers in shared decision making is borne out by separate development of approaches that are similar in spirit and in many particulars, under names that include participatory modeling, mediated modeling, and computer aided negotiation.

With current headlines about water conflicts from Texas to California to Georgia, taking a fresh look at how to infuse collaboration into water planning and decision making, we at IWR, along with our colleagues at Sandia National Laboratory and the U.S. Institute for Environmental Conflict Resolution, felt it was time to share experiences about the use of transparent, collaboratively developed (or at least vetted) models to facilitate multi-stakeholder public decision processes. This desire to bring together collaborative water modeling practitioners with conflict resolution practitioners was the motivation for this workshop.

The workshop reflects the current interest in collaborative processes and specifically in the support of collaborative processes with jointly conducted technical analysis. Collaboration is a focus of the federal government's watershed approach, the Bureau of Reclamation's 2025 program, and the White House's cooperative conservation initiative. In 2007, the White House's Subcommittee on Water Availability and Quality (SWAQ) identified collaborative tools and processes as a key element in a federal water research strategy and recommended an interagency federal initiative on "the integration of computer based modeling tools within multi-stakeholder public decision processes for US water solutions." CADRe is an approach that is designed to integrate technical analysis with collaboration to improve the outcomes of water planning and decision-making processes. The workshop provided a timely opportunity to further advance and promote the development and implementation of CADRe processes for US water solutions.

The Workshop Itself

The workshop consisted of panelists talking about the origins, evolution and motivation of CADRe; presentations of eight case studies; panel interviews and discussion; and an open space discussion forum. Below is a summary of the workshop presentations and discussion, which are more fully detailed in the rest of these proceedings.

To set the stage for the discussions, workshop chairs Len Shabman and Kurt Stephenson presentedan overview paper on CADRe that had been distributed prior to the workshop. The paper defined "computer assisted" (CA) as the development of computer models to support water management decision making, and Dispute Resolution (DRe) as interest-based negotiation to resolve water resource management disputes. The overall goal of the workshop was "Bringing CA to DRe: How and when does simulation modeling add value to a water resources negotiation process?" The presentation outlined distinguishing characteristics of CADRe: 1) That collaborative development of computer models is integrated into the negotiation process, 2) Models are explicitly designed in conjunction with the negotiation process, and outputs from simulation model(s) are used as a focal point for conversations. CADRe assumes:

- Joint learning and mutual discovery are key for building consensus
- Knowledge is fragmented; complex systems limit the ability of anyone to comprehend all interactions.
- Decision-making through learning is iterative and so preferences evolve with improved understanding.

- Normal routines, regulations, etc. simplify day-to-day decision making but can limit awareness of possible opportunities and creative solutions.
- Science and technical analysis cannot stand alone from policy and should be at the service of decision-making.
- Decision-making is not strictly an analytic exercise but also must incorporate societal values.

With the stage set, the workshop featured presentations by people who were trying to bring the "computer assisted" to "dispute resolution". First, early practitioners – Rick Palmer, Dan Sheer, and Bill Werick, and one of their "clients" – the International Joint Commissions' Lisa Bourget presented their perspectives on CADRe and were interviewed by the workshop chairs. This was followed by a "round robin" of eight additional case study presentations that looked at different ways that "computer assisted" was being applied to "dispute resolution" in water resources. From the east to the west cases included applications in Washington, Idaho, Oregon, New Mexico, Colorado, California, Pennsylvania, and the Great Lakes. Topically, they involved: municipal watershed and water supply planning, reservoir operations, groundwater management, transboundary resource management, drought planning, and groundwater management in regions dominated by irrigated agricultural. Presentations were from water managers at the federal, interstate, and irrigation district level, as well as by consultants.

The second day featured panels with "process practitioners" interviewing modelers, and with federal agencies giving their challenges on the use of CADRe in their agencies. Modelers shared their sometimes embarrassing stories that highlighted the limitations of good modeling without a correspondingly good process. Federal agencies shared some of the policy challenges to increasing the use of CADRe.

Finally, the workshop participants formed six Working Groups for further discussion concerning aspects key to the maturation of CADRe as discipline. The groups and their discussions focused on:

- *Neutrality and objectivity in CADRe processes:* CADRe is predominantly a social and political process and not a scientific process. The objective of a CADRe process is to arrive at informed conclusions about how a public resource should be managed given public preferences and values. All people have prejudices and biases, including facilitators, modelers and those who try to combine those two roles in leading CADRe processes.
- *Integrating CADRe into NEPA* – How CADRe can be incorporated in conducting collaborative NEPA processes. Can CADRe be used to speed up NEPA processes that need to be implemented as quickly as possible? How can we overcome institutional obstacle such as internal organizational resistance to collaboration, difficulties in engaging other agencies to collaborate, and generation of leadership support for a collaborative approach to NEPA and use of CADRe*?*
- *Education and Training in CADRe* – The cross-disciplinary nature and nascent stage of CADRe as a field creates educational challenges at all levels. Practicing engineers/ modelers need to gain the skills needed to facilitate or at least participate productively in CADRe sessions. How do we attract, educate, and retain "CADRe-friendly" people and

overcome the "silo effect" at many academic institutions at the undergraduate and graduate level?

- *Community Building and Outreach – the Wiki* – The results of the Albuquerque CADRe workshop need to be widely publicized, through wide distribution of the proceedings and through a special edition of a journal. Potential other venues to announce the results include conferences, the next World Water Forum, and the American Geophysical Union's EOS newsletter. To promote follow-on and continuity, we need an interactive Web presence (the wiki) with information resources on CADRe.
- *CADRe software and models* – Cultural shift is needed to allow other people to come into the modeling process. With Shared Vision Planning, a primary purpose of collaboratively developing models is to build mutual trust. Desired model characteristics include: transparency, effective graphic visualization, accessibility, integration, and flexibility. How can available commercial products be linked to more complex tools; How can simple models capture the important dynamics of complex models; how can we employ an OpenMI approach for model coupling; How do we embed regional processes spatially to integrate in a state plan; Where do "expert systems" fit in as a guide to CADRe processes?
- *Research Needs* – Research needs include more synthesis from many applications rather than individual case study write ups and descriptions, the development of Performance Measures for CADRe processes, demonstration projects where concepts can be tested and further developed, graphic visualization needs, and the interface of CADRe with Integrated Water Resources Management. The research needs from the other working groups will be incorporated into the CADRe research agenda.

Next Steps

The energy and excitement from the workshop was palpable as the participants left committed to forming a community of practice to grow the community and maintain contact among the participants of the workshop. Beyond individual case studies, the community felt a need to go to the level of synthesis of various applications with an eye towards developing a set of best practices. In addition to widely publicizing and distributing the results of the workshop, the participants wanted to keep informed and connected, most likely through an interactive web portal that would distribute case study and education materials, and serve as a forum for follow-on discussion from the workshop.

With the publication of these proceedings the first order of business is complete, and the task becomes follow-through on the many items identified from the breakout groups (above) as we jointly strive to further develop and promote CADRe. The three co-sponsors of the workshop and the breakout group leaders will be initial focal points for activities that will grow as the CADRe community widens and develops. Over the next few years we envision increased professional inter-agency and inter-disciplinary discussion and applications of CADRe. Through applications and research into those applications - both domestically and internationally - we envision a process of "learning through doing". We now have a publication based on these proceedings, and there will be additional conference sessions and workshops within and across agencies on CADRe. We see increased interest in both water agencies and academic institutions leading to more educational programs focusing on the intersection of CA and DRe. Such interest will lead to more applications. The combination of methodological research and applications will promote new best practices of the application of CA to DRe. Within a decade, we see CADRe ideas and tools becoming the norm for water resources management nationwide and globally - promoting more durable, publicly supported and sustainable solutions.

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	**Case Study Forum: Round 1**	
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	**Case Study Forum: Round 2**	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	**Networking Reception**	

Friday, September 14th

8:30 - 8:45 **Welcome, Plan for the Day**

Franciscan Leonard Shabman and Kurt Stephenson

8:45-10:00 **Panel Interview**

Franciscan ***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 **Panel Discussion**

Franciscan ***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 of Computer-Aided Dispute Resolution: Approach and Evaluation

Kurt Stephenson
Virginia Tech

Leonard Shabman
Resources for the Future

Outline

I. Introduction
II. Setting the Stage for CADRe
- Interest Conflict
- Value Conflict
- Cognitive Conflict
- Authority Conflict

III. Bringing CA to DRe: Three Levels of Integration
1. Building a Model Credible to Decision Participants
2. Building a Model Useful to Decision Participants
3. Using a Model to Reach Agreement

IV. Bringing CADRe to Contemporary Water Policy: Some Challenges
- Participation of Water Resource Management Agencies in CADRe
- Developing CADRe Capacity
- Developing CADRe Acceptance
- Scientific Expertise and CADRe Models
- Justifying CADRe: The Public Interest Test

V. Conclusions

I. Introduction

Computer-aided dispute resolution (CADRe) is an approach to decision making that supports negotiation among multiple 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. 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.

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 (See Box 1). Computer aided (CA) makes reference to computer simulation models – and perhaps visualization – to predict outcomes (or performance) of different actions (alternatives) taken to manage water or human behaviors in a watershed. CADRe includes systematic methods and processes to natural resource decision-making that would be grouped under a general approach to decision making described as analytic-deliberative processes (National Research Council 1996, 2005; Maguire 2003)

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?" How CA and DRe can be brought together is the principal focus of this background paper. The implicit premise behind this 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 (an agreed upon alternative) 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." This is a matter we discuss further in Section 4.

Surprisingly little overlap exists between the two areas of work. The research and practitioners often exist separate from each other and the work in one area rarely influences the work in the other. 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). Numerous government agencies' programs and environmental management initiatives now include collaborative decision-making, or enhancing stakeholder collaboration, as a central theme. An element of this literature also studies and assesses the conditions and barriers to successful negotiations (Wondolleck and Yaffee 2000; Koontz et al. 2004; O'Leary and Bingham 2003; Bauer and Randolph 2000). The literature extends to the normative question of which stakeholders should be party to the negotiation. 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.

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 physical action. 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. The technical 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 (a single government agency) who has trust in the model and the authority to make a choice among various alternatives.

Box 1: The Domain of CADRe

The explicit integration of technical computer modeling into group problem solving for 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. Each method 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).

At one extreme, collaborative computer model building might 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 a plan, but disagreements often can be resolved by modifying the vision or the plan, especially if that modification requires no immediate action or budget decision. We reserve the concept of Computer Aided Dispute Resolution (CADRe) for those situations at the other extreme, where collaborative computer model building is initiated because there is a current or anticipated disagreement over a specific action (e.g. considering a permit for a pollutant discharge permit or re-operation of a dam) and/or budget decision. In this instance, the prospect of immediate and real consequences for decision participants makes it likely that disagreements will be difficult to resolve and collaborative computer model building is seen as a means to bring agreement that would otherwise be impossible to achieve.

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 specific premises about human decision-making. Specifically:

- CADRe accepts the premise that knowledge is fragmented, dispersed among the decision participants and can be formal (technical training) and informal (based on experience and understanding of local conditions) (Ozawa 1991). Further, there is a limited ability of any participant to comprehend and understand all the relationships with the complex system (Lindblom 1990; March 1982; Vennix 1999). CADRe computer simulation models and group collaboration can facilitate a broader and shared understanding of system relationships and consequences.

- CADRe resists the tendency of decision participants to simplify the range of choice, the alternatives considered and the assessment of consequences in order to deal with the problem of complexity.

- CADRe accepts the premise that decision participants often have difficulty separating arguments about “what should be” from arguments about “what is.” CADRe is designed to organize negotiations to reach agreement on what is, and then focus attention on what should be.

- CADRe resists the tendency to let technical analysis proceed with its own problem definitions, alternatives and solutions. 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. Models should be at the service of decision-making, not the means of deciding (Ozawa 1996).

- CADRe accepts the premise that decision-making is iterative with learning as stakeholder preferences are developed or discovered when confronting choices (Vatn and Bromley 1994). CADRe accepts the premise of collaboration literature that learning and discovery are the keys to reaching consensus for decision making. Psychological research provides substantial evidence that preferences for outcomes are contingent on past experiences and an understanding of the costs and consequences of existing alternatives. The discovery and creation of new alternatives means that preferences among alternatives change and evolve.

In CADRe, computer simulation modeling is to *aid* the stakeholders in discovering their preferences, as they jointly explore alternatives and options with the modeling in support of the discovery process. In contrast, some decision support approaches (such as benefit cost analysis and multi-attribute utility analysis) seek to elicit preferences and values of stakeholders independent of an actual choice situation. Then the analysts develop a model that simulates outcomes from different alternatives that might be chosen, where the model is developed by technical experts. The analyst sees their role as identifying what outcome and hence alternative should be preferred, given the elicited preferences. In this approach to decision support, the experts are expected to identify the “optimal” alternative for the decision participants.

Given points above, CADRe processes will seek to discover and create alternatives and options that can improve and advance the interests of all decision participants (called integrative bargaining). CADRe processes will recognize that 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 this broad outline, 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; Lund and Palmer 1997; 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, STELLA, 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.

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 DRe 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 2003). 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.

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 (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.”

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) is 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.

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. Beyond clarifying sources of conflict, it is unclear the extent to which CADRe processes can successfully manage intense value conflict.

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. Decision makers then 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 the number of disciplines (and subdisciplines) and "experts" have 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 2002).

Authority conflict

United States water resources decision-making is often described as if it were the product of the formal distribution of intergovernmental and intragovernmental 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 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.

Decentralized governance is how one author describes the current situation (Rogers 1993), while others refer to civic environmentalism (Landy and Rubin 2001), or to the democratization of environmental decision making (Ingram and Schneider 1998). 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.

III. Bringing CA to DRe: Three Levels of Integration

Conceptually, integration of CA with DRe can occur on three different levels: 1) model development, 2) stakeholder objectives and modeled output (performance metrics), and 3) 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.

1. 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.

The model construction process provides a forum for decision-participants to share knowledge and information and enhance joint understanding of relationships within the system. CADRe model construction is a way to organize and coordinate data, stakeholder knowledge, and scientific knowledge into a coherent framework. Conventional modeling approaches envision the role of the scientist and technical modeler as providing analysis and models to the decision-makers. CADRe approaches allow for 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 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, a process must be designed for technical experts and decision participants to cooperatively develop a common simulation model of the water resource system. 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 CADRe processes stress the direct collaborative construction of a model 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. Joint fact finding efforts can be part of coordinated efforts for decision-participants to develop the data foundation, technical relationships, and response functions within the model. CADRe model development process may draw upon multiple data sources and unique knowledge bases, including both formal expert and informal user knowledge of the system. Indeed, some imply that the *process* of model development yields benefits to the decision process at least as important as the actual model itself (Grayson, Doolan and Blake 1994).

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 system elements relate to each other (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.

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 stakeholder opposition to developing response functions based on expert judgment processes when data quality/scientific information is low.

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 modelers undertake standard procedures for calibrating and verifying simulation models in order to increase their own confidence in the internal consistency of the model logic, in a models ability to predict the outcomes of interest, and/or in order to have a sense of the magnitude and direction of error in model predictions. However, these procedures cannot establish the accuracy of the model predictions, defined as how closely the model approximates the “true” value of some predicted outcome (Oreskes et al. 1994). CADRe processes offer another, and unique, process for verification by requiring the data, structure (technical relationships), logic and predictions to “make sense” to the decision participants most familiar with the decision problem and to their technical support staff. Equally important, if decision participants do not have confidence that the model adequately represents the system of concern, the CADRe models will be of limited value in negotiating agreements.

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 policy acceptance (Sheer, et al. 1989; Dahinden et al. 2000).

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 (Dahinden et al. 2000; Korfmacher 1998; Roach and Tidwell 2007).

2. 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 driven by the questions of interest to the modelers or framed by scientists and technical experts. 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 reasons for asking these questions should be guided by participants and care must be taken to avoid embedded or hidden value judgments in the model that are the appropriate domain of the negotiations. The distinction is often difficult to separate and identify in practice. For example, the objective of one stakeholder group might be to protect and enhance some biological measure of the status of a particular fish species. This interest might ask the question, "What timing, magnitude and duration of water flow is needed to produce a healthy (or sustainable) fishery for species X?" Framing the question in such a way, however, requires the technical analysts and modelers to define "healthy" and "sustainable." Modeling becomes centered on trying to answer what is healthy or sustainable, but both definitions are ultimately policy, not technical, 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 (fish species X), 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 (1998, 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."

CADRe processes also recognize that decision participants 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.

In addition, CADRe technical models must also produce answers (model results) in a form useful to stakeholders if they are going to be effective participants in dynamic, iterative negotiations. Performance metrics are measures or indicators of outcomes that have been identified by the decision participants themselves and reflect their underlying interests and objectives. Identifying measurable outcome 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 2004). A CADRe process that is planned and conducted to require decision participants to articulate, identify, and then agree on specific performance metrics is critically important to producing effective negotiations. Just as important, however, the process of developing identifiable performance metrics is a learning process that requires stakeholders to narrow and sharpen their own thinking about what aspects of the problem are important and critical to their interests and values.

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 2004). 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 2004). 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.

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). In other cases, performance metrics may be expressed as graphical or picture form, rather than numerical form. Developing performance metrics that resonate with various stakeholders is often one of the most creative and difficult challenges to developing CADRe models (Sheer, 2007). 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, 1979; 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).

3. 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 technical computer 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.

A number of design issues must be addressed on how CADRe technical models are integrated into collaborative negotiations over outcomes and alternatives. One such issue involves decision participant access to technical models. 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 (Dahinden et al 2000; Roach and Tidwell 2007). CADRe process must also decide how decision participants socially interact with each other and the model.

Gaming exercises are one way to 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.

Through the use of performance metrics, technical models can demonstrate cause and effect and reveal tradeoffs for decision participants. 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. CADRe model design must seek effective ways to 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. For example, models algorithms might be designed to remove clearly “inferior” alternatives. Inferior alternatives are those that cannot improve (or actually decrease) the desired outcome of any performance metrics compared to a baseline alternative.   Werick describes the use of “fence post” alternatives that bound the range of feasible alternatives (Werick 2007). The degree to which multiple performance metrics are aggregated or condensed to facilitate tractable discussions of tradeoffs and alternatives itself becomes a deliberative decision.

IV. Bringing CADRe to Contemporary Water Policy: Some Challenges

There are barriers to as well as benefits and barriers from negotiation for dispute resolution (O’Leary and Bingham 2003). The focus of this effort is not on negotiation and collaboration per se, but rather the intersection between negotiation and technical analysis/models. 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. Thus if multiple agencies are among the conflicting parties, then an outside entity may need to be the convener, facilitator and financial supporter of a 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/integrated licensing 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. However, some agencies my view such sanctions

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 or might not meet 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 narrow 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 (Maquire 2003). 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 of choice 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.”

Agencies that must choose 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.

Developing CADRe Capacity

In many CADRe applications, analysts/modelers are also facilitators who have a mindset of expanding the gains from agreement to all parties and helping to analyze complex tradeoffs in terms agreeable to participants. Professionals with modeling and facilitation expertise are in a 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 effort, analysts’ skills should include not only technical modeling expertise, but skills that enhance productive engagement in collaborative processes, including the ability to probe assumptions, to 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 effective participation and leadership in CADRe processes (Vennix 1999).

Because CADRe processes rely on computer simulation models as an integral part of how decision participants formulate and evaluate policy alternatives, it is essential that the modeling platform and structure increase likelihood of mutual learning and discovery of better alternatives. This creates not only certain requirements for the skills of the analysts, but also circumscribes the kinds of technical approaches that can be used. CADRe simulation models must be designed and constructed to support collaborative negotiations. These models will predict the physical, biological, or economic outcomes in the water resource system associated with different policy alternatives or future conditions, so that decision participants in a collaborative and negotiation process can collectively debate and then decide among alternatives as they explore the consequences of the alternatives and at the same time define their preferences for different outcomes. Such models invite decision participants to identify trade-offs between competing objectives and then to collectively discuss and debate whether physical, biological or economic improvements justify the losses.

Such an approach differs from many decision analysis tools proposed or advocated within the water resources literature. Such analytical tools or models include comprehensive benefit/cost analysis or multi-attribute utility analysis. These approaches purport to construct response models of the water resource system and then measure or weigh the preferences or values decision participants place on all outcomes of alternatives. Such models weigh and aggregate stakeholder preferences either in dollars (benefit-cost analysis) or a system of subjective weights (multi-criteria analysis) into single quantitative rank alternatives that aims to identify the "best" or "optimal" alternative. Such approaches rely on analysts and analytical models, not collaborative negotiations, to identify the preferred alternative. In some applications, however, multi-criteria analysis might be used as a preference clarification tool to help focus stakeholder attention on their evaluation of tradeoffs, and would not rely on the subjective weighting to select a preferred alternative (Rodrigo 2007, NRC 1996).

Thus, CADRe simulation models are *decision aids* rather than *decision optimizations*. CADRe models are designed in support of collaborative negotiations and not intended as a substitute or replacement for them. CADRe processes avoid the presumption that models can decide for negotiating parties due to behavioral assumptions implicit in the approach including individual preferences are being created and revised during negotiation and the inability of analysts to collect and know all values relevant to decision participants. As decision *aids*, CADRe models require a greater familiarity and understanding between technical modelers and collaborative process facilitators/negotiators.

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 (FERC 2001).

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.

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. Perceived roles of these technical experts may at times work against agency staff support for CADRe processes.

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 are built on existing scientific understanding, but may 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 (Korfmacher 1998; Reckow 1994). Indeed, in certain settings, many CADRe models maybe, by design, 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, technical and scientific experts within agencies frequently have some decision making responsibilities. These technical staff may not always understand or appreciate the modeling needs of the collaborative process.

In other situations, agency staff and scientific experts may be reluctant to participate in, or support, CADRe efforts because of perceptions that stakeholders (often non-technical stakeholders) are too uninformed or biased to reach the "right" decisions. CADRe processes require that some decision-making authority be vested with the negotiating group. CADRe processes also require involvement and participation at multiple levels of the decision process (including the technical analysis) and from multiple stakeholder groups. Scientists (within and supporting the agencies) may perceive that such participation would compromise the technical credibility of the technical analysis. A recent survey of scientists in the northwest United States found that scientists support public involvement in the form of review and comment but do not believe they should be "equal partners" in making natural resource decisions (Lach, Steele and Shindler 2005).

Furthermore, the participation of stakeholders with clear and narrow political or economic interests may be viewed as producing decisions not in the "public interest". 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, 2001, 4).

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 argue, does 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)?”

V. Conclusions

CADRe processes do not pretend to eliminate or reduce conflict but rather to create a setting in which conflict can be more effectively managed and perhaps mediated toward reaching agreement among participants with competing values and interests. Agreement is envisioned when CADRe processes facilitate joint learning while building social trust and understanding among participants in the process. In turn, this joint learning and social trust creates both the motivation and opportunity to discover alternatives that are more acceptable to a broader range of stakeholders.

Successful CADRe processes integrate computer-based simulation models with collaborative negotiation processes in the ways described in this paper. Integration occurs at multiple levels including study scope and problem identification, data collection, water resource simulation model development, definition of performance metrics, and identification and then evaluation of alternatives. This said, CADRe processes cannot guarantee that mutually agreeable decisions will be reached among affected stakeholder groups. Indeed, it is likely that agreement can be reached upon cognitive conflicts, but it is not certain that successful management of cognitive conflicts will lead to productive dialogue and debate over value or interest conflict. Thus what CADRe promises is not agreement, but another path to the possibility of agreement. Given the challenging contemporary water policy setting, the experience to date (including case presented at this workshop) suggests that in many instances CADRe can be that path.

Today the art and practice of CADRe remains under development. Practitioners often work in isolation from one another and opportunities for shared learning are few. During this workshop the discussion lifted up a number of fruitful areas for research, development, education and shared learning – all to address the challenges described in the last section of this paper. The workshop was an initial effort to form an active community for CADRe practitioners where this necessary work can begin.

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CADRe Origins and Motivation

This session brought together the early innovators to discuss how and why they came to their own approach to CADRe. The following presentation, with editorial supplements, describes what it is they do, and how it may have evolved during 20 years of experience.

A Process for CADRe and Requirements for Tools to Support CADRe
Daniel Sheer

Shared Vision Planning: A Personal Perspective
Richard Palmer

What I do, How I do it, and Why
Bill Werick

A Process for CADRe and Requirements for Tools to Support CADRe

Daniel Sheer

***Written Preface to Presentation*:**

The attached slides supported a presentation on one way to run a Computer Aided Dispute Resolution process. HydroLogics has used this particular approach to help resolve a number of very complex multi-party disputes. The slides emphasize the importance of the early stages of the process – particularly the development of performance measure displays for all of the parties and then the development of a tool set for producing those displays for all the alternatives to be evaluated.

HydroLogics has found that the development of effective visualizations of the relative performance of alternatives is extremely important. When this development is done in a collaborative setting, it greatly enhances communications and understanding between the stakeholders in a dispute.

The slides also emphasize the importance of developing a capable tool set prior to actual CADRe sessions. The tool must be able to produce the displays. Just as important, the must be flexible enough to evaluate all viable options, especially options involving more effective operating policies. It is all too often the case that the lack of ability to evaluate creative options precludes their consideration – in other words, the imagination of the CADRe participants will be limited by the tools at hand.

While it is desirable to have tools that all stakeholders can use directly, this is usually an unreachable goal. Many stakeholders simply will not take the time or do not have the resources to utilize complex analytical tools on their own. As a part of the process outlined in the slides, HydroLogics provides a human interface to the tools. As a practical matter, this allows all stakeholders to evaluate alternatives, either on their own or collaboratively.

The slides do not cover the difficult task of convening a CADRe process. In HydroLogics experience, the fact that some of the stakeholders are developing performance measures and credible tools tends to draw in other stakeholders. It may be that the motivation for additional stakeholders to join the process is the possibility that their interests may be ignored in solutions that result.

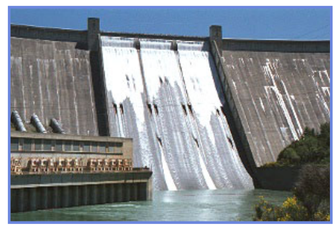
In every dispute where HydroLogics has used the process outlined in the slides, CADRe has succeeded because it has been relatively easy to find a wide range of solutions that make all parties better off than they would be by preserving the status quo. In some part this is due to the ability to target alternatives at more clearly defined objectives. In larger part this is due to the abysmal state of the practice of water resources management, rooted as it is in conflicting legal mandates, politics rather than science, and perception rather than fact. CADRe can go a long way to improving the state of the practice.

- *Dan Sheer*

HYDROLOGICS

Advancing the management of water resources

A Process for CADRe and Requirements for Tools to Support CADRe



Daniel P. Sheer
September 13, 2007
CADRe Conference

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HydroLogics is or has been involved in a many disputes

- Delaware
- Susquehanna
- California
- ACF/ACT
- Everglades
- Potomac
- Tar
- Rio Grande
- Yellow River
- NYC
- Kansas River
- Waterbury
- Roanoke
- Rivanna
- South Saskatchewan
- Las Vegas

HYDROLOGICS

Our Role Depends on the Needs of our Client(s)

- Mediator
- Advocate
- Advisor
- Expert witness

HYDROLOGICS

We Use Science to Help Resolve Disputes

- Combination of engineering and mediation
- Science helps determine
  - The proposed alternative is practical
  - The proposed alternative is effective at achieving expected results
- Mediation implies all value judgments are made by client (participants)

HYDROLOGICS

All Water Problems are Disputes

- Water resources problems are multi-objective problems
- Even if there is only one party, deciding on the balancing of objectives is equivalent to resolving a dispute

HYDROLOGICS

HydroLogics' Uses a Process

- Order of tasks is often critical
- Effective process is more important than tools (models)
- Identifying objectives is the most important part of the process
- HydroLogics takes a pro-active role and maintains a neutral position

HYDROLOGICS

Objectives of a Collaborative Decision Process

- Overall objective - Find a set of operating "rules" and facilities that "work" for all parties
- Individual objectives vary
  - Fisheries management
  - Power production
  - Riparian habitat management
  - Recreation, etc., etc., and so forth
- All are legitimate

HYDROLOGICS

CAN - A Collaborative Process

- Consensus on PERFORMANCE MEASURES (Objectives)
- Consensus on DATA
- Consensus on METHODS
- Consensus on ALTERNATIVES
- Design of Analytical Tools
- Joint Development of Tools
- Mediator Assisted alternative development and evaluation

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CAN vs. Mediation

- To convene of not to convene…
  - Mediators often convene
  - In CAN, one or more of parties convenes and expenses can be shared
- To propose or not to propose…
  - Mediators and CAN facilitate communication
  - CAN facilitators propose alternatives

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Maintaining Neutrality

- Neutrality in a multi-objective sense
- Values are expressed as
  - Objectives
  - Weights
- HydroLogics avoids specifying either regardless of role
- Advocates adopt clients objectives and weights

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Ensuring that Alternatives are Non-Inferior

- Alternatives proposed by a CAN facilitator must be non-inferior (Pareto-Optimal)
  - Usually impossible to prove that no superior alternative exists
  - Responsibility to try to find one still exists
- Facilitator should attempt to identify superior alternatives to those proposed by others

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What Is A Performance Measure?

- A display
- Compares alternatives for one or more management objective
- Needs only to distinguish "better" and "worse"
- Water management is multi-objective
- Multiple performance measures are required

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Performance Measure Notes

- HydroLogics rarely tries to commensurate performance measures
  - Single scores are not informative IMHO
- If it is not possible to evaluate a particular performance measure directly, we use surrogates

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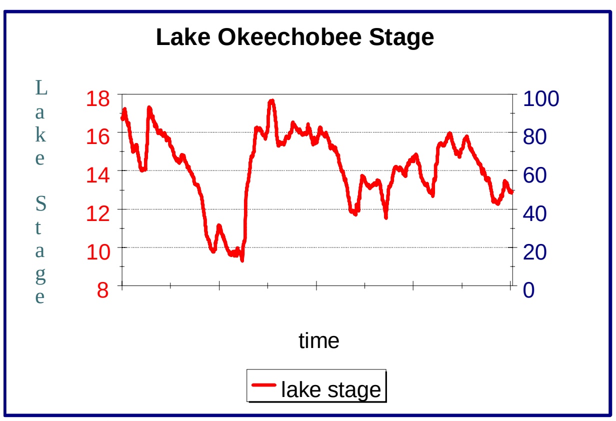
Process for Developing Performance Measures



8 1997 Water Resources Management Inc.

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Scientific Rationale

- No habitat if lake stage exceeds 15 feet
- No forage if lake stage reverses by more than 6 inches

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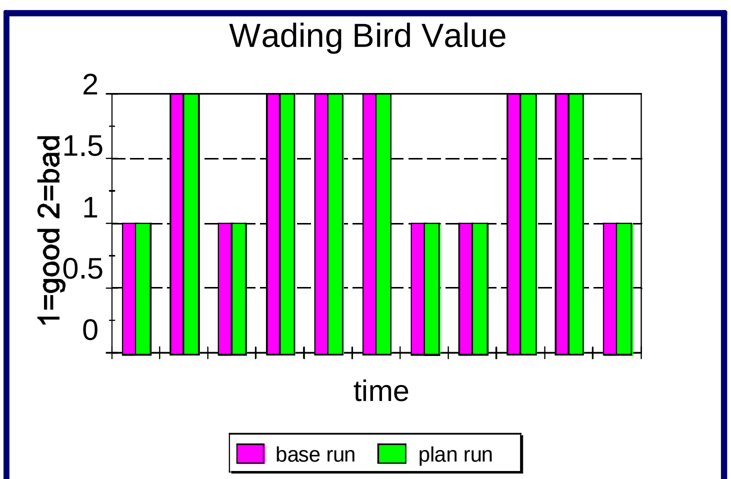
Performance Measure First Attempt



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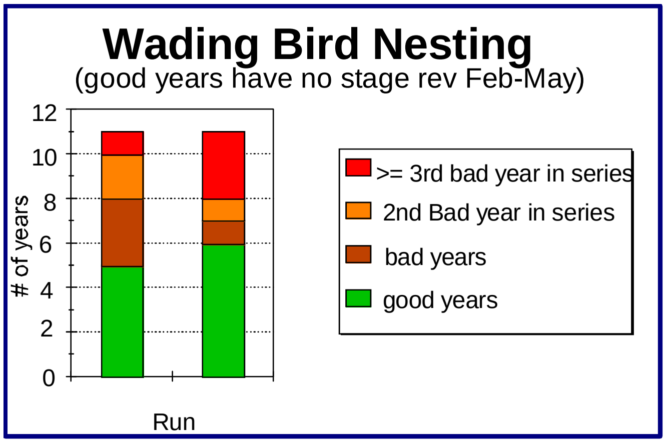
Performance Measure Revised



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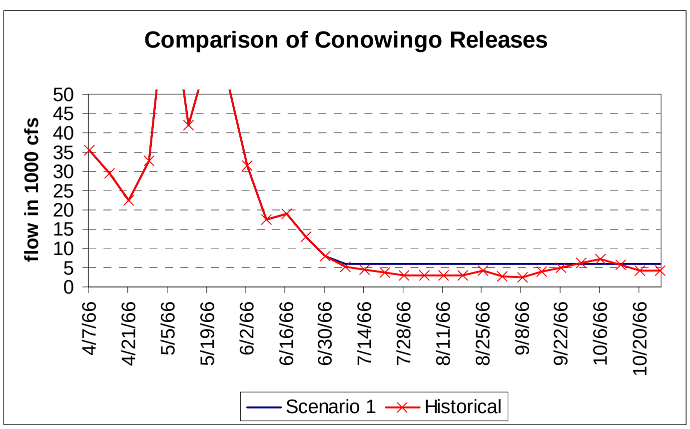
Performance Measures - Surrogates



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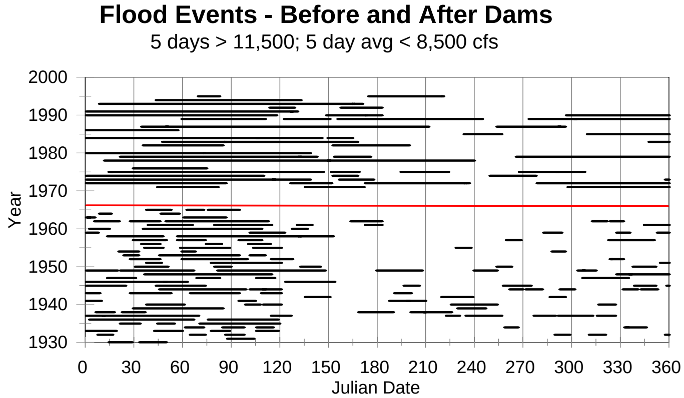
Performance Measures - Surrogates



Models in the Collaborative Context

- Almost always, management models are used in collaborative processes
- In order to develop agreeable and implementable solutions, most, if not all parties need access to models

What's a Model, and What's a Model Good For, Anyway

- An abstraction of some reality
- You can test the "goodness" of the abstraction by comparing it to the real world (research models)
- You can attempt to predict the future (or discover the past) using the abstraction (management models)

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Types of Models

- Empirical (e.g. regression or neural network models)
- Mathematical cause and effect models (e.g. hydrodynamic models) - physical models
- Structural models (e.g. the USACE SF Bay Model, AI models - sometimes)
- Human Behavior Models (e.g. economic models and OASIS)

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Management Models vs. Research Models

- Research models try to simulate history in order to determine how the world works
- Management models assume that we know how the world works, and try to evaluate the impacts of actual and potential human actions on the future

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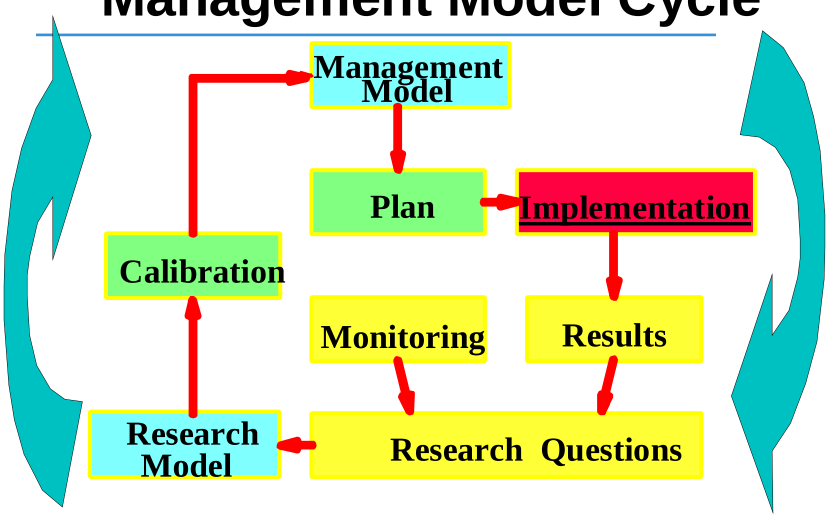
The Research Model - Management Model Cycle



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Choosing Models

- “My object all sublime,
  I shall achieve in time,
  To let the punishment fit the crime,
  The punishment fit the crime.”

from “The Mikado” by Gilbert and Sullivan

Model Requirements

- Appropriate time step – often daily
- Ability to model physical features with sufficient accuracy and precision
- Ability to model physical system changes
- Ability to model human operations
- Reasonable run times and ease of use

Human Operations

- Operating rules are often more important than facility modifications
- Rule based operations
  - Rule curves
  - Strict if – then – else rules
- Goal seeking operations
  - Enumerating all cases for rule based operations is impossible IMHO
  - Goal seeking operations involve balancing objectives (optimization)

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Operations Strategy (How Do Humans Behave? Badly, of Course)

- Optimize short term
- Rules set short term objectives
- Short term objectives are surrogates for long term operating objectives
- Operating rules have both forms and parameters
- Models must provide flexibility for forms and parameters

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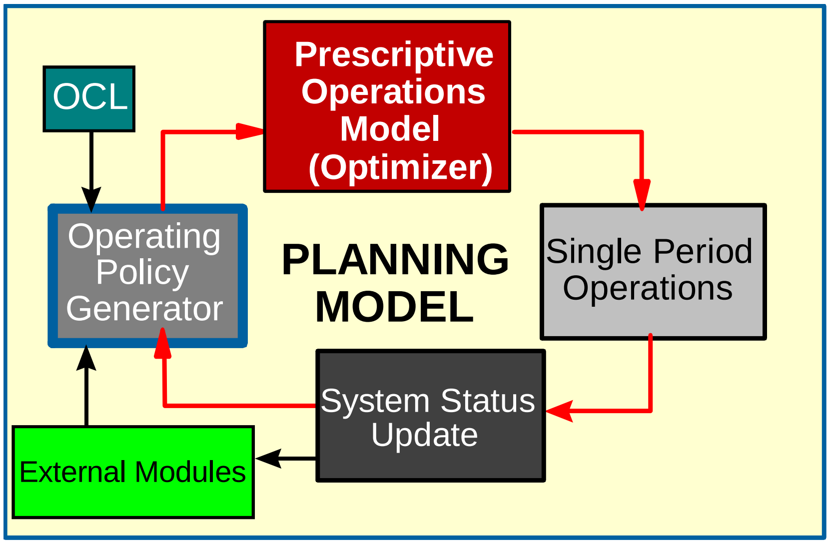
OASIS Flow Chart - Simulation



Using Management Models

- Many modelers think:
  - They can build the “perfect” model
  - Play around with it
  - Solve the world’s problems
- THEY ARE WRONG!!

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How Model Building Helps

- Builds a common understanding
  - Objectives (performance measures)
  - Physical Reality
  - Law and regulation
- Provides credible evaluations
- Allows collaborative alternative development

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Models Must be Credible and Accessible

- In CAN or CADRe, access to models levels the playing field
- Models can be distributed
- A human interface to models will need to be provided to some participants

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Conclusions

- Getting good performance measures is the single most important task
- Use model building to build common understanding
- To the extent possible agree on science and data before doing analysis
- Make sure the tools are adequate
  - Physical side
  - Human behavior side
- Provide meaningful access to models

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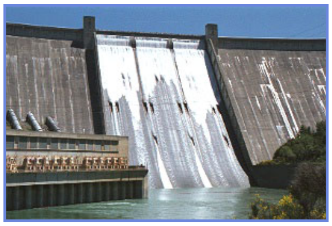
Advancing the management of water resources

Thank You!



Presenter
Daniel P. Sheer
June 24, 2002

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Shared Vision Planning: A Personal Perspective

Richard Palmer

***Written Preface to Presentation*:**

The Albuquerque workshop may well prove to be a watershed event for those of us that have been engaged in Shared Vision Planning (SVP) for almost 20 years. What is often unclear is that the principles of SVP were not developed at a leisurely pace in the confines of an academic or government "ivory tower" but instead in the middle (or end) of highly charged water resource conflicts where planners were seeking tools and approaches to solve real problems.

The principles did have the benefit of immediate application, thus we did see almost instantly if an idea would not work well. However, as developers of a concept, we had the disadvantage of not having the opportunity to take a more deliberate, broader view of other potential approaches.

This workshop brought together a wide range of researchers interested in participatory planning, all of whom saw the benefits of incorporating interactive computer modeling into the process. Because we came from different backgrounds and have had different experiences, the opportunity for real exchange of new ideas was possible. In many of the previous conferences and workshops I have attended, SVP was viewed as a somewhat unique water of doing water planning. At this workshop, the framework was significantly expanded and all those attending benefited.

My hope is that the parties at the workshop can now return to the basic principles that have been developed to critique and improve what was often formalized in a "just in time" fashion by those of use trying to solve problems before the budget (or time) ran out. Watching what has happened in Atlanta recently relative to their drought reminds us of the need for not only doing good planning but seeing it implemented and institutionalized. Those of us who worked on their water supplies in the 1990's know that a framework exists that would have resulted in much better management had it been followed. Perhaps an improved SVP process (that could result from these types of conferences) should be reapplied there.

-Richard Palmer

Shared Vision Planning: A Personal Perspective

Richard N. Palmer. Ph.D., PE

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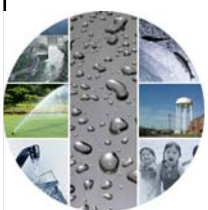

Presented at the
Workshop on Computer Aided Dispute Resolution (CADRe) Workshop

Water Resources Management and Drought Planning Group

Albuquerque, NM
September 13-14, 2007

UNIVERSITY OF WASHINGTON

CLIMATE IMPACTS GROUP

Shared Vision Planning: A Personal Perspective

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UMASS AMHERST

Outline

- My definitions
- How it started for me, the Potomac
- Virtual Droughts
- Shared Vision Planning
- Observations

Definition

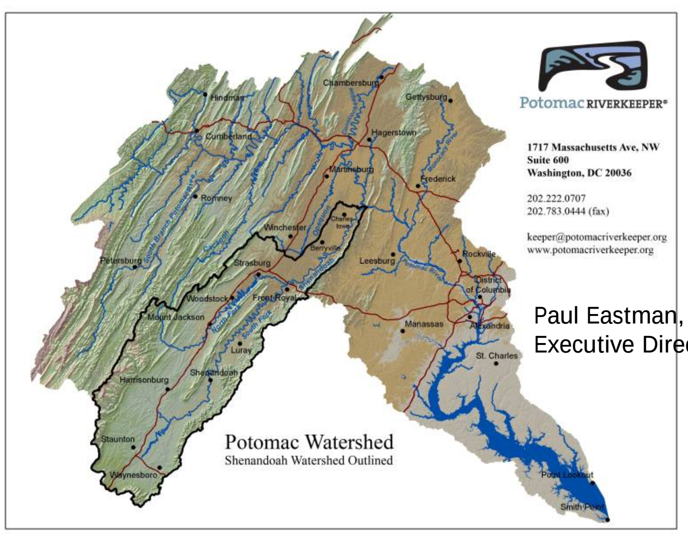
- Shared vision planning is a collaborative approach to formulating and implementing water management solutions with three essential components:

1) traditional water resources planning,
2) integrated computer modeling, and
3) structured public participation.

Definition

- Computer-aided dispute resolution (CADRe) is an approach to decision making that supports negotiation among disagreeing parties with computer simulation models.

Potomac River



Paul Eastman,
Executive Director of ICPRB

Potomac River Basin Challenge

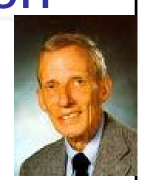
- Problem Setting
  - Dispute between Corps of Engineers, Northern Virginia, Southern Maryland, in the Potomac
  - 16 major reservoirs suggested
  - Number had been reduced to 6
  - LP model suggested that 2 reservoirs could supply needs if only there was

    Cooperative Management!

Linear Program

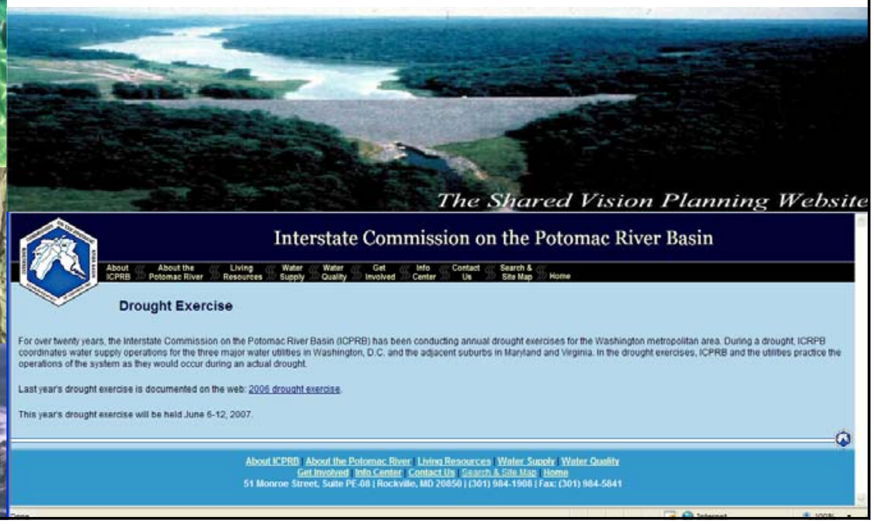
- Large Scale Linear Program
  - Clearly demonstrated flaw in previous approaches
  - Suggested that droughts were not basin wide
  - Results caught no ones attention
  - Perhaps the computing environment at that time was not what it is today

Interactive Simulation



- Pete Loucks at Cornell had led the way
- Hopkins team took the insights from LP and placed them in early “interactive simulation” models
- Demonstrated in a workshop several regional options to the system operators and managers.
- Demonstrated increaed benefits and how to practice for droughts.
- Created a new perspective
- Nominated as Civil Engineering Achievement of the Year 1983

- Erik Hagen has substantially improved the process, evolving it into an annual event



Moving Forward

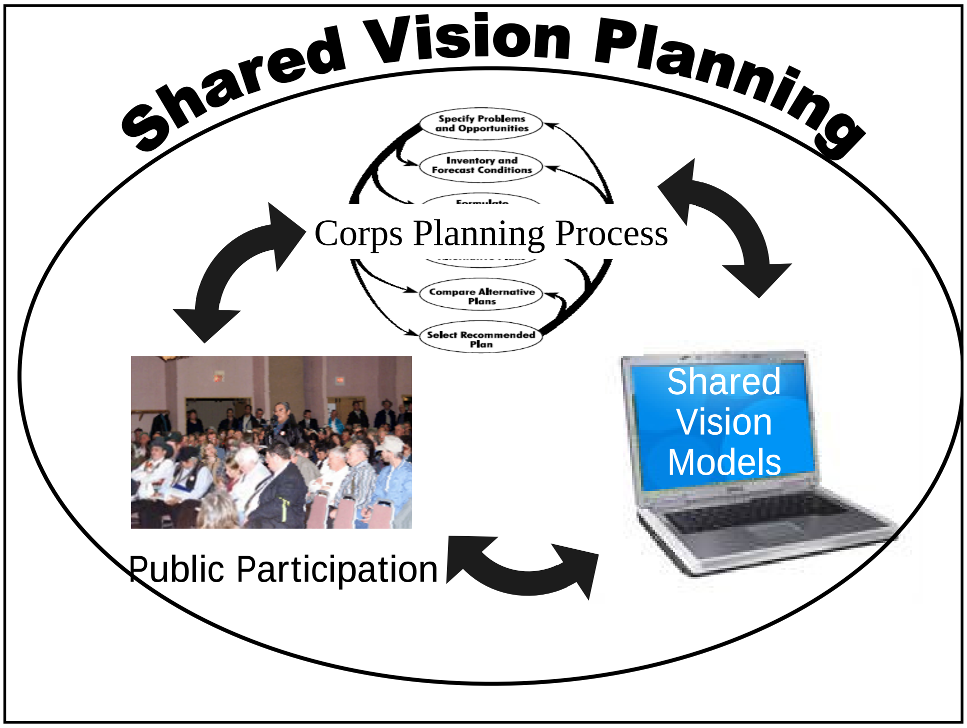
1991

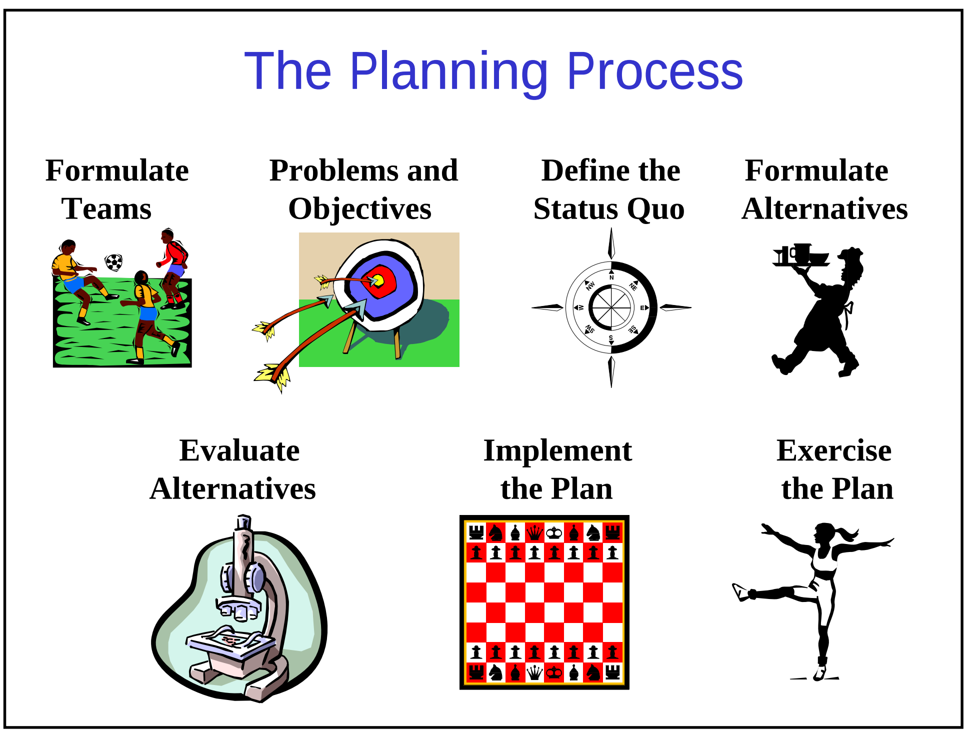
Shared Vision Planning

- National Drought Study, early 1990s, the Institute of Water Research (IWR)
- Case Studies developed to identify opportunities
- Emerging interactive computing environments
- Economic and Environ. Principles and Guidelines for Water and Related Land Resources (P&G).
- I was not trained in water "planning processes."
- Werick
  - "Models were expensive and rarely completed on time, that they typically did not incorporate those system components most important in real decision-making and management, and that often they cost more than they provided in useful planning insights."
- Brian Mar – Shared Vision Planning – Boeing Aerospace Corporation

Shared Vision Planning

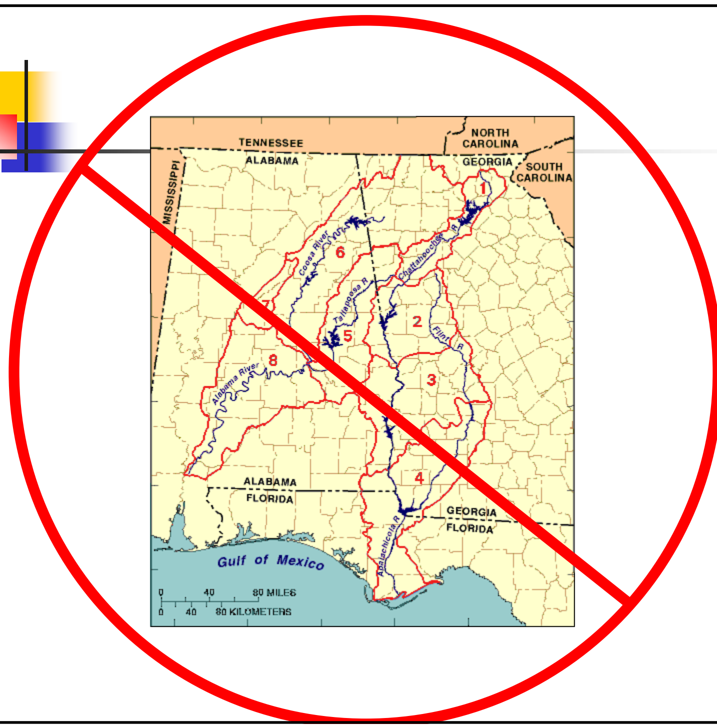
- Together, with study partners, proposed, modified, refined, and applied ideas of Shared Vision Modeling.


Shared Vision Planning
Specify Problems and Opportunities
Inventory and Forecast Conditions
Corps Planning Process
Compare Alternative Plans
Select Recommended Plan
Shared Vision Models
Public Participation


The Planning Process
Formulate Teams
Problems and Objectives
Define the Status Quo
Formulate Alternatives
Evaluate Alternatives
Implement the Plan
Exercise the Plan

Moving Forward

1994



Observations

1) Future water resources managers and planners will be different than their predecessors.
2) Negotiations of conflicts will become more sophisticated and difficult.
3) Computer tools will change and will likely offer new frameworks to help resolve conflicts.
4) People want disciplined and organized approaches to water planning and management (unless they are already winning).
5) It’s a stakeholder world.
6) The “Study Process” is as important as content

What I do, How I do it, and Why

Bill Werick

***Written Preface to Presentation*:**

For me, the enticement of the Albuquerque workshop was the chance to shape an identifiable whole out of the many like-minded approaches to producing better water management decisions faster and with lower transactional costs. National environmental legislation of the late 1960s and early 1970s such as NEPA, the Endangered Species Act and the Clean Water Act at first made such a positive contribution, but now these dusty laws make significant water management decisions difficult to make in any reasonable amount of time. The Congress has been unable to seriously consider revisions and reauthorizations to any of these laws, so we are like Cubans with our 1958 Impalas, trying to keep the things we used to admire so much running. I'm always pleased when people I've never met champion shared vision planning, but I notice it because it's an exception. Many of the folks at this workshop have been using these methods for over a decade, and on some fairly high profile case studies, but because there is no single name and no home for what we all (more or less) do, it's been difficult to get the news of these improved approaches out. That means water managers and NGOs use more adversarial methods. Universities teach outdated ideas, and students go into other fields because they abhor the bureaucratic standstill that characterizes our profession. We can't get noticed even at a time when water is a favorite subject of the media. I never expected this one gathering to change all that, but I do expect this meeting to be the beginning of the end of our anonymity (definition, the state of having no known name or identity or known source). It's important for us to notice and question the differences in our approaches so the methods can be improved and taught. But it's more important to recognize our commonalities so these methods are used more regularly.

- *Bill Werick*

What I do, how I do it and why?

Bill Werick

Presented at the Workshop on Computer Aided Dispute Resolution (CADRe) Workshop
Albuquerque, NM September 13, 2007

What I do

1991

- Along with distrust of modelers, NDS brought planning and public participation methods I had learned in the Corps but modernized to Seattle
- Corps planning focused on whether and how to invest federal money; the "Drought Preparedness Study Method" assumed multiple decision makers, no federal money
- Circles of Influence participation went out instead of in

Decision makers and stakeholders not supplicants

What's different about SVP?

What's in a name?

Computer Aided Dispute Resolution	Shared Vision Planning
Resolves disputes	Creates a new, collective vision
May even lead to a new point of view	New vision has to appeal to disputants
Often pairwise	Typically multitudinous
So if a computer helps resolve disputes it's CADRe?	Single system model built with some sort of collaboration to build trust

Why I do it

- Because I hope to make things better
- I don't want a Pope – I'm changing my religion:
  - Models bad → Collaborative models good
  - Decision support software good →
    - Decision support software annoys already angry people →
      - Informed consent good
  - That STELLA guy → That Excel guy →That browser guy
- It's about heaven, not church

What distinguishes us here from them there?

- We each play different roles but more or less subscribe to a canon of principles around a systems approach to the craft of water management

Dan Sheer
Dan Rodrigo
Vince Tidwell
Rick 1980 Rick 2007
Bill 1980
Bill 2010
Len Shabman
Erik Webb
Hal Cardwell
Jerry Delli Priscoli
Jim Creighton
Ane Deister
Lisa Bourget
Chandler Peter

Why I'm here

- Because we are being discovered too slowly
- Because it's shameful that we don't have a collective space to compare and improve our craft
- Because I'm doing more shared vision with less shared vision modeling
- Because our disputes can gestate better methods
- Because few are going to heaven and it's time for modelers and planners to ask the dispute resolution guys what we could do differently

Water Wiki

- Think medical community, with a central spine of agreement that excludes faith healers and edges of growth that allows and tracks experimentation, eventually recognizes acupuncture
- Principles and case studies, papers and toolkits, debate forum
- Sanctioned by ASCE and AWRA
- Limited editing access
- Developed initially by contract, turned over to a joint ASCE-AWRA Board
- Funded ($100k/year) by Energy and/or Army
- Managed at IWR

CADRe Case Studies

A Comparison of the CADRe Process: Perspectives from the Gila, Rio Grande and Willamette
V. Tidwell, T. Lowry, J. Roach, A. Sun, and H. Cardwell

Use of Modeling to Facilitate Interstate Collaboration on the Lower Susquehanna River
T. W. Beauduy and A. D. Dehoff

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

Climate Change and Water Planning in the Northwest: A New Application of Shared Vision Planning.
R. Palmer

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

Solving Urban Watershed Problems in Los Angeles through the Use of Collaborative Planning
D. Rodrigo

Changing the Rules for Regulating Lake Ontario Levels
B. Werick

Drought Preparedness in Northern California –People, Practices, Principles and Perceptions
A. Deister

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

Vincent Tidwell, Tom Lowry, Jesse Roach, Amy Sun
Sandia National Laboratories

Hal Cardwell
Institute for Water Resources, U.S. Army Corps of Engineers

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 stakeholder groups increasingly include collaborative model building as an effective way to inform the decision process. Examples of collaborative modeling 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 applications 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 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.

We begin by reviewing the basic features characterizing each of the three CADRe case studies. Geographically, these case studies are associated with the Upper Gila River and Upper Rio Grande in New Mexico and the Willamette River in Oregon (Figure 1). A brief description of the implementation of CADRe within the differing settings is then given. Finally, a discussion of the key forcings and their influence on the CADRe process is considered. It should be noted that each of these projects are in relatively early stages of the planning process. Specifically, efforts to date have focused on the model development aspects prior to any application in formal decision making. Thus, perspectives shared in this paper are conditioned on this timing.

Background

Below we provide a general description of the setting for each of the three CADRe projects. In particular, we characterize each with respect to the three key forcings: physical setting, available modeling toolset, and decision landscape.

Figure 1. Case study test sites.

<u>*Gila:*</u> 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 Cristo 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, impending demands include support for water rights adjudication and changing instream flow requirements. 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 for irrigation, inexpensive power generation, 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 the case studies differ in terms of their physical setting, availability of water management models, and the decision landscape, so to 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.

Gila: In the Gila Basin the NMISC in cooperation with the SWPG, the U.S. Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife 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 address 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 an expanded decision space.

Again, a cooperative modeling team was formed; however, it is populated only by technical representatives from state and federal water agencies; specifically, scientists and modelers from the United States Geological Survey (USGS), the USACE, Reclamation, and the NMISC. Collaboration occurred primarily through monthly to bi-monthly meetings over the last year. These meetings focused on the abstraction of the physical relations and data contained in the higher resolution models for use in the decision support tools, specifically reviewing the general framework, assumptions, and methods employed. In this way the resulting decision support model reflects the science and data of the higher resolution models, while the necessary upscaling is accomplished according to the knowledge and experience of the cooperative modeling team.

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 to have a limited role in the model development phase, focused on defining the overarching model scope and decision metrics. Technical aspects were left to the review of a group of local experts who had experience in modeling temperature dynamics on the Willamette. This team consists of representatives from the USGS, USACE, Portland State University, and Oregon Department of Environmental Quality. The team functions in much the same model development capacity as that of the cooperative modeling team for the Middle Rio Grande. Additionally, this advisory role is intended to 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

In this section we compare and contrast application of the CADRe process across the three case studies. First, we consider similarities shared across all three projects. We then turn our attention to differences in application and the relation of these differences to the key forcings characterizing the three projects.

Indeed, all three case studies share important similarities in their application of CADRe. In fact, the similarities represent some of the key characteristics distinguishing CADRe processes. First, each case study was faced with a challenging suite of decisions involving the interplay of complex physical, institutional and legal systems subject to a growing and diverse set of demands and values placed on the water resource. Second, stakeholders in all three projects recognized a need for computer-based tools to support the decision process. Even in situations where detailed and trusted water management models existed there was a need to make the science and subsequent scenario analysis accessible to the stakeholder. Third, the stakeholders required that the model development or abstraction process be transparent; that is, they wanted some level of involvement in modeling. In each case the stakeholders took an active role in defining the scope of the model, decision metrics, and oversight of the technical content.

Likewise, there were significant differences in the details characterizing the CADRe process in each of the case studies. Although all three CADRe models were developed in a system dynamics context, each differed in terms of the scope, spatial/temporal resolution, and the physical/social attributes modeled. These differences were at the direction of the cooperative modeling team and are a result of the variability in project setting and the decision landscape. The availability of existing water management models had the effect of improving the quality and confidence in the CADRe model.

Another important difference was in the composition of the cooperative modeling teams. The Gila Cooperative Modeling Team had the broadest stakeholder involvement and the most active participation. The momentum generated by the early stages of the Arizona Water Settlements Act planning certainly had a strong influence on this level of participation. Other contributing factors included the lack of trusted water management models and thus the desire for careful oversight by the team, and that the Gila is the last free flowing river in New Mexico which provided a rallying issue for both local, state, and national environmental interests. The Willamette also enjoyed broad stakeholder participation; however, participants requested that the technical issues be handled by a smaller sub-committee. The stakeholder team was willing to relinquish some of its control and involvement because of the trust and confidence developed with the technical experts and models through interactions on past planning efforts. These past efforts also created a sense of "planning fatigue" and thus the desire to limit time spent in meetings. Stakeholder participation in the Middle Rio Grande was limited to state and federal water managers. This was driven by the decision landscape in which there was a desire to take proactive steps toward preparing for future planning efforts. Because of the lack of a specific planning driver and limited resources involvement by a broad stakeholder team was impractical.

The mode and frequency of stakeholder meetings also differed across the three case studies. The highest frequency meetings (bi-weekly) occurred in the Gila, largely because the model development process was starting from scratch—no models existed prior to this effort. The monthly to quarterly meetings of the Middle Rio Grande and Willamette teams reflect the fact that model development was largely an abstraction exercise from existing models. The mode of the participation in all three case studies included face-to-face meetings. However, in the Gila, where participants were geographically dispersed yet there was a need for high meeting frequency, web/voice conferencing was used

Finally, the role of CADRe within the broader planning context differed across the three case studies. In the Gila project, the CADRe process worked in parallel with other science and public outreach efforts. CADRe was simply one piece in a broader effort. However, the Arizona Water Settlements Act planning project was recently stalled by a Governor's veto because of a lack of balance across key interest groups. This resulted in a request by the NMISC and Governor's Office for the Cooperative Modeling Team to facilitate efforts to re-structure the broader planning process. While the effort on the Willamette also involved a distinct planning driver (new temperature TMDL), there was no coordinated state or federal response. Also, over the course of the CADRe project the compliance time was shifted from 18 months to ten years. This change in compliance timing has made it much more difficult to maintain stakeholder focus in the effort. The Middle Rio Grande represents a very different case in which a "preemptive CADRe" planning effort was established in efforts to avoid future conflict. While there are significant advantages to developing planning tools and creating an environment of cooperation among water managers prior to conflict, there is the distinct danger of not having broader stakeholder involvement in the model formulation stage. We will take this experiment to the next stage as we engage a broader group of stakeholders in tailoring and applying the model to look at alternative conservation storage options in upstream reservoirs.

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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. Participation remained open to any interested party throughout the process, but invitations to participate were extended directly to targeted 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. Importantly, all targeted parties were active in Workgroup activities. The Workgroup met several times a year and provided direction, oversight, input, and review for the planning effort and its results. Other interested parties that did not directly participate were kept apprised of the Workgroup's progress.

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. The OASIS software was chosen based on its successful application in the Delaware River basin. SRBC had used other software to model certain extents of the basin, but they were not specifically designed for water resource analysis and lacked the flexibility and multi-objective capability of OASIS. The services of the creators of OASIS, HydroLogics, Inc., were also retained to develop the model and provide guidance in the modeling and CADRe process.

The 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 and basinwide estimates of existing and future consumptive water uses, the model included representations of the operation of large public water supply withdrawals, power plants, and reservoirs in the Susquehanna River Basin. The stakeholders were as directly involved in development of the model as possible, from providing operating data to reviewing and verifying modeled operations. Due to this direct involvement, there was good confidence by the Workgroup that the model accurately reflected current operating conditions.

Using the 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) to perform efficient evaluations of the long-term implications of changes in operating policies and facility configurations. Comparative output displays of Conowingo pond levels and dam releases allowed the Workgroup to evaluate the numerous operation alternatives and make recommendations for the management of the pond. 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 further 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.

Arrival at the consensus recommendation is attributable entirely to the lessons learned from using the model. The exercise provided new insights that helped to dispel preconceived ideas of how best to solve the low flow problems of the Conowingo Pond. For example, as mentioned above, use of upstream reservoir storage did not address the problem as well as some Workgroup members anticipated. Likewise, most members were surprised to find that the system – including downstream releases – as a whole functioned better under scenarios implementing a credit for leakage earlier in a drought than later.

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. Workgroup members, although no more bound to continue participation as they were during the initial process, seem committed to extending their roles through the follow-up activities. The need for the Conowingo facility to undergo relicensing by FERC in 2014 is no doubt an incentive; much of the work conducted thus far by the Workgroup will be revisited in that process and play a role in the development of new license conditions. The relicensing process will also likely cause additional stakeholders to become interested in Conowingo operations. Any with a direct stake in the operation of Conowingo Dam during low flows will be invited to join the Workgroup.

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. However, the resource is still not without limitations, and it is just one part of a much larger system. There exist many potential conflicts and future unknowns, ranging from large diversions to impacts of climate change, which cannot necessarily be accommodated under the recommended management plan. The recommended related actions by SRBC and others will serve to acknowledge the limitations of the resource and be important in planning for the ongoing management of the Susquehanna River basin.

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 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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Notes from the Presentation:

The above paper was provided as background material for participants in advance of the workshop. Additional detail was provided during the presentation and in through the discussion that followed. Included were the following topics:

- Who were the “stakeholders,” “water managers” and “decision makers”?
- The “RiverWare™ version of CRSS is now the officially accepted version of the model.” Did all stakeholders and agencies accept this model’s outputs? How was this trust in the model created?
- What was the role of the public engagement (scoping) in the model development process? How did the public contribute to the model?
- The difference between the full version and the “Lite” version was the timestep (monthly vs. annual). Did participants voice concern about this loss of resolution?
- BuRec worked with modelers from Cooperating Agencies, Basin States and NGOs individually and supported the groups in the development of their preferred alternatives. How important was the communication between stakeholder groups about the alternatives they were developing? Were planning objectives specified and evaluated against performance measures, or did the modeling reveal critical performance measures that were used to label one alternative better than another?
- What were the opportunities for collaborative learning of each others’ positions, values or concerns?

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 evaluate 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 researchers' 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 its 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.

Because of the nature of climate change science, 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 21st 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.

Notes from the Presentation:

The above paper was provided as background material for participants in advance of the workshop. Additional detail was provided during the presentation and in through the discussion that followed. Included was the following information:

- When this project started, the purpose of forming the task group was to quickly (over a few meetings) make a list of foundational points everyone could agree on. But, surprise, surprise - it turned into a long ordeal. During the process that ended up closer to 1 year, several people who originally rejected climate change changed their views and accepted the basic principles.

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 improved aquifer management, 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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Idaho Water Resource Board. *Eastern Snake River Plain Aquifer (ESPA) Comprehensive Aquifer Management Plan Framework.* February 2007. Available online at: http://www.espaplan.idaho.gov/2-16-07%20ESPA%20Framework%20FINAL.pdf.

Notes from the Presentation:

The above paper was provided as background material for participants in advance of the workshop. Additional detail was provided during the presentation and in through the discussion that followed. Included were the following topics:

- IWRB said there was no need to talk to more than 15 people, but CDR interviewed more than 90.
- Tribes were also involved in the Advisory Committee.
- During the presentation, the author described each stakeholder group as having its own expert, and that the experts are their own cabal. There were questions about whether the model was answering the right question/ that the nodes in the MODFLOW model were at the right scale to answer questions – that the model "was good enough for planning but not for regulation."
- How were working groups differentiated? Were they heterogeneous (focusing on different issues) or homogeneous (multiple, generic working groups)?
- Was there overlap between the ESPA Advisory Committee and the ESHMC?
- This is a case of a "legacy model," since the ESPA Advisory Committee were not involved in the development stages, and had to be brought up to speed on it. Is there any option for model modification, or is the education about the model one-way?
- It sounds like the model was collaboratively modeled by technical people and is now being proposed to help resolve management disputes. The existing legacy model's structure (a) may or may not be trusted by all stakeholders, and (b) model outputs may or may not be in terms of performance measures that resonate with some stakeholders.
- What has been the level of transparency and flexibility in the model platform, and has this been important to the process?
- What were the specific objectives and performance measures developed?
- During model development and the Framework, were conflicts/disagreements encountered and satisfactorily resolved? How happy were the groups with the resulting model?

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

Dan Rodrigo
CDM

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.

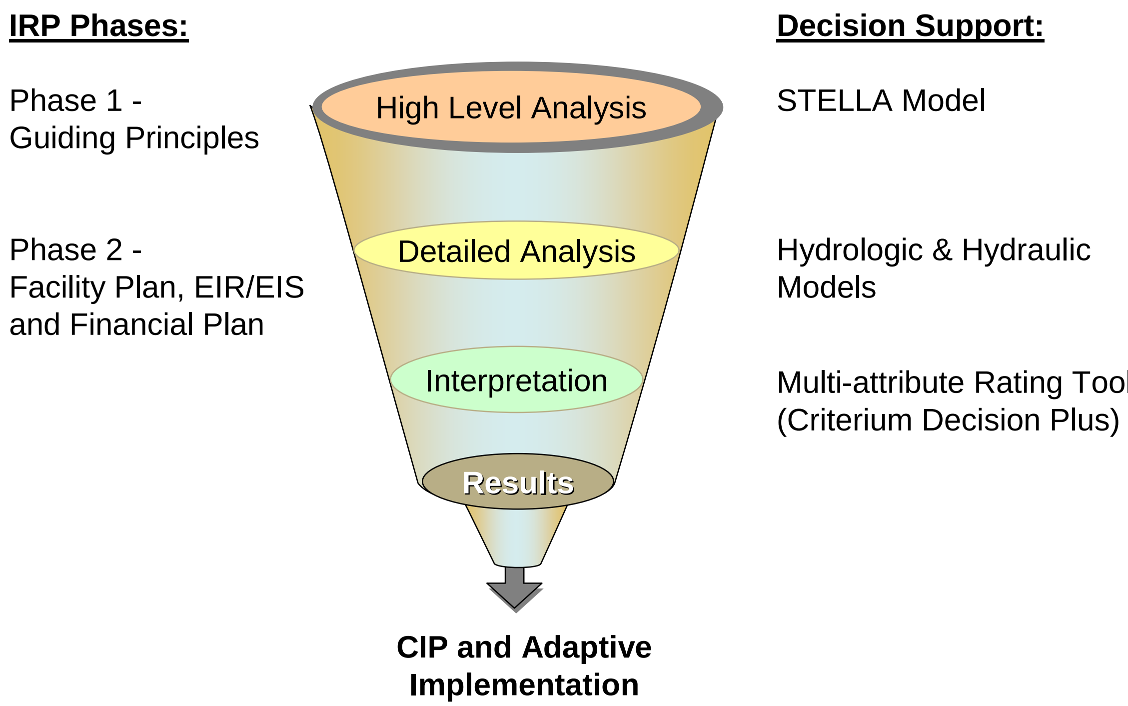


Figure 1
Overall Analytical Process for IRP

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 build (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.

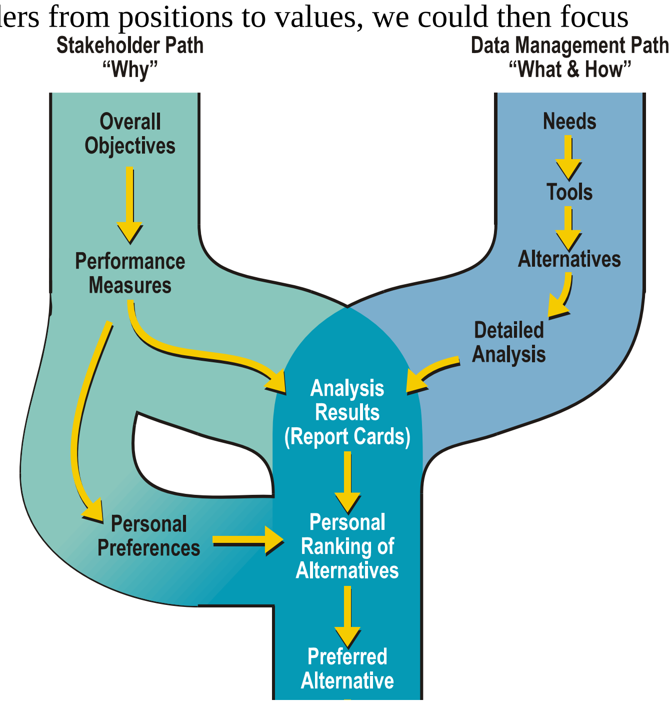


Figure 2. Decision-making Paths

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, 372 stakeholders representing over 1,500 organizations and/or interest groups within the City were committed to participating in the IRP:

The stakeholders were broken into three tiers:

- Steering Group
- Advisory Group
- Information Group

Members of the Steering Group represented the Los Angeles population as they provided their inputs/concerns. They committed to attending a total of 13 half-day workshops conducted over a three-year period. At these workshops, the Steering Group had two basic roles:

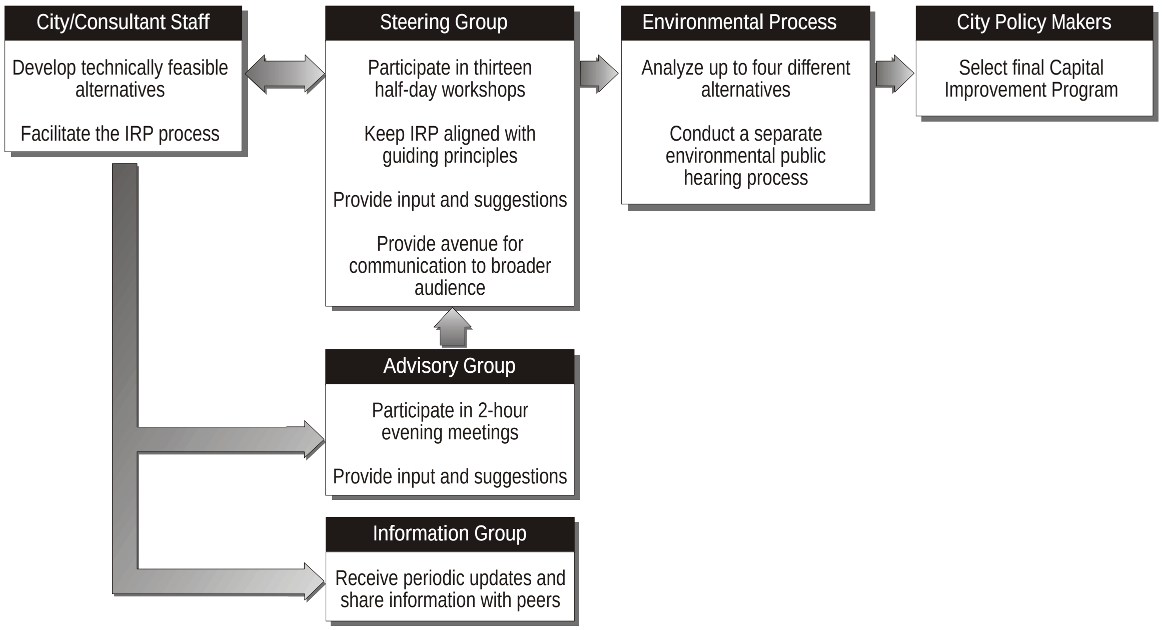
- To provide an on-going input on a regular basis on technical, environmental and financial development of the project; and
- To consider key project issues, such as facilities siting, implementation risks, and acceptability of costs that would invariably arise during the project.

Members of the Advisory Group participated in regular evening meetings 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.

All interested parties were invited to stay informed of the facilities planning effort. Members of the Information Group received periodic newsletters to inform them of major milestones and recommendations of the IRP effort.

Figure 3 illustrates the relationships between the City and the stakeholders. These relationships provided the City with integral feedback from the stakeholders through Steering Group workshops and Advisory Group evening meetings; this interaction was designed to make sure that the IRP was aligned with the guiding principals developed in Phase I. The final outcome of this process will include a collaborative stakeholder-driven selection of a set of alternatives that will go through the environmental process discussed previously.

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.

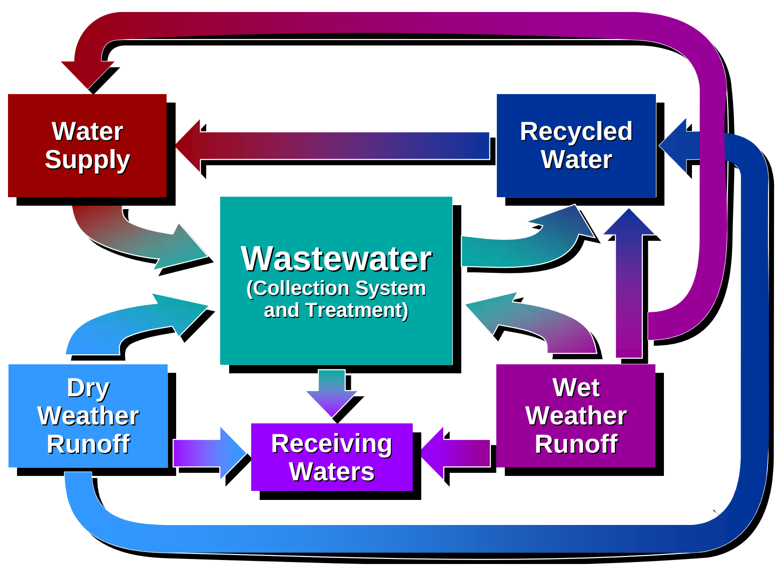
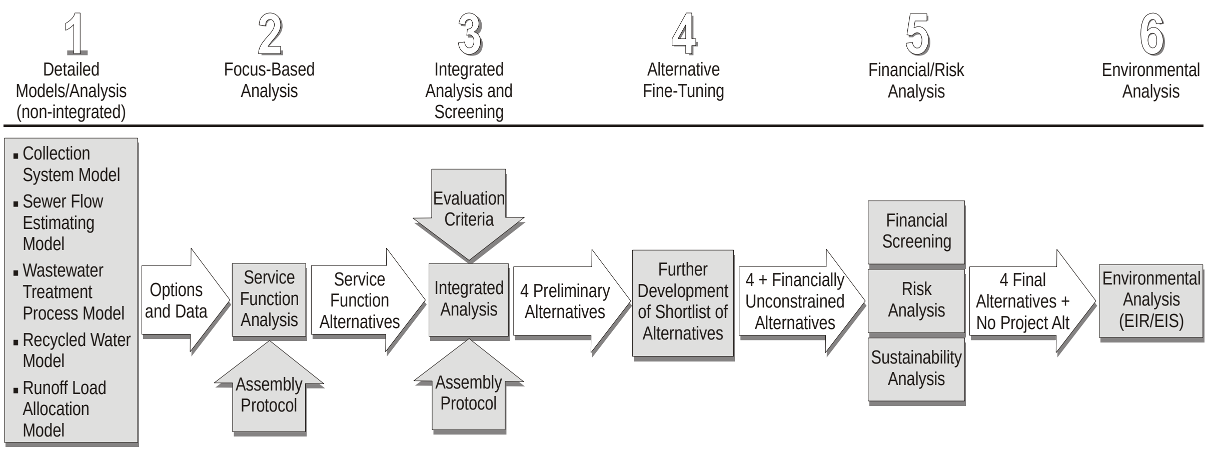


Figure 4.
Interrelationship of City's Water Resources

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.

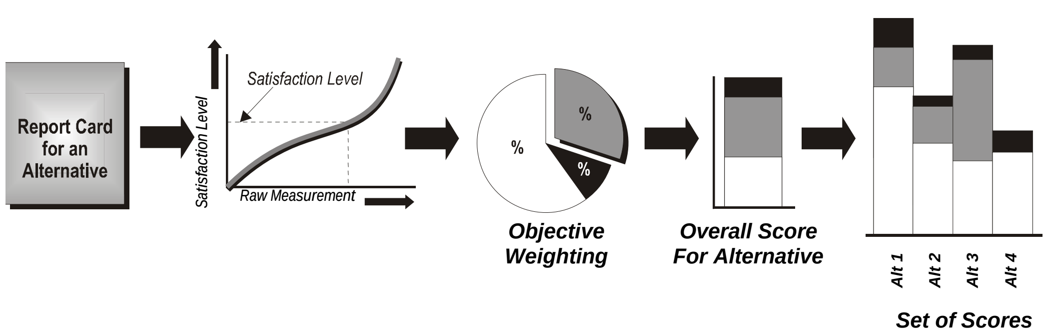
During Phase 2, detailed modeling was necessary for wastewater, stormwater and recycled water planning. Hydraulic models and hydrology simulation tools were used. Figure 5 presents the analytical approach used during this phase. Stakeholders were still very much a part of this process as well. They reviewed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



The outcome of this process was: (1) broad consensus on a preferred alternative from over 25 alternatives evaluated; (2) an approved facilities plan and certified environmental document; (3) settlement of pending lawsuit on beach closures; and (4) a voter approved City bond of $500 million to pay for project implementation.

Notes from the Presentation:

The above paper was provided as background material for participants in advance of the workshop. Additional detail was provided during the presentation and in through the discussion that followed. Included were the following topics:

- The workshops moved people from alternative-focused thinking to values-focused thinking in order to identify common ground. How were these general values then used to work toward developing collaborative solutions and attaining consensus?
- What were the performance measures and how were they developed and used in model development?
- Who participated in the process and how were they selected?
- Which stakeholders interacted with the model to test alternatives and learn about the system? (Any particular group described in Figure 3?)
- Did the model include a spatial dimension (as would be required to assess the benefits of locating a new wastewater plant near potential users)?
- What were the "policy principles" adopted by the City Council?
- Describe the detailed models developed in Phase 2. Were they also built with STELLA, or based on existing models that linked to the system model?
- During Phase 2, was there any distrust on the part of the stakeholders? If so, how was it resolved?
- The description in Figure 6 implies that the decision-making process was treated as a linear optimization problem; however, the description in the presentation showed that it contained iterative thinking about the relative weights and rankings.
- CADRe envisions that there is an integration of this process with models. It is in the process of simulating consequences of alternatives on performance metrics and costs within a budget constraint that stakeholders discover preferences and tradeoffs and reach agreement. How was the budget constraint understood in the process (the preferred alternative cost $5 billion, but only $500 million was ultimately available)? If the $500 million budget (or a budget constraint of some amount) was recognized at the outset how might process/outcomes have been different?
- Can you elaborate on the outcome? What was the alternative? Did the city council adopt recommendations without change? Any dissenters from broad consensus? How arms-length was the city policy-makers to steering group?

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 STELLA 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. The PFEG reported to the Study Board and the Study Directors. The original membership was made up of those who had pushed the Board to make the formulation and evaluation of alternatives – planning – an identifiable and managed task rather than a natural happenstance of the technical studies. 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 blue boxes collectively were the SVM in design and use, not just the STELLA model. The shape of the research and models mimicked in many ways the relationships between the TWGs and the Study Board. For example, all TWG work products had to contribute directly or indirectly to the shared vision model. PFEG had no authority over the TWGs but PFEG advised the Board on how TWG research proposals would or would not support the Board's decision making process. 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

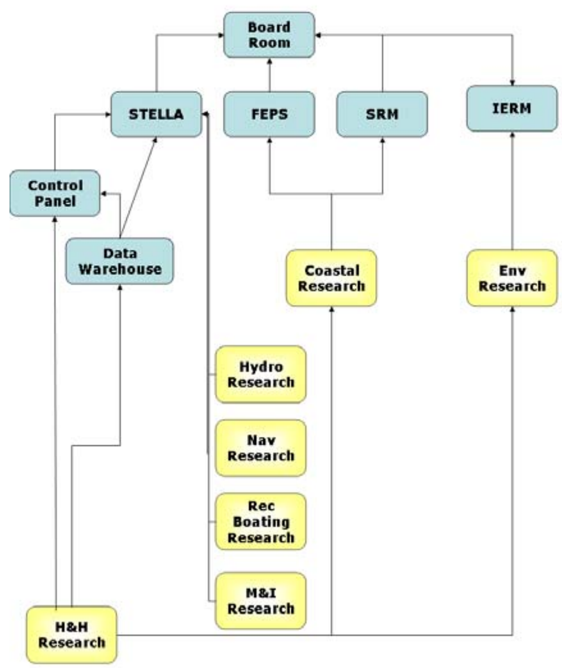


Figure 1. SVM Structure

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.

- **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). PFEG 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 to 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 (SVM). 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. For example, the FEPS model was proprietary and impervious to casual review. PFEG found substantial errors in the FEPS model by close review of its documentation and results, but no one reviewed the code. In the end, many of its processes could have been programmed in STELLA or Excel where review would have been easier. Similarly, the IERM modeled the wetland algorithm in an essentially opaque code. After the study it became apparent that there were small differences between the researcher’s coding of the algorithm, the IERM coding, and subsequent attempts to model the algorithms in Excel. While the mathematical differences were not great and the resulting conclusions identical, in retrospect there are three good reasons for modeling the wetlands in easily accessible code. First, it would have allowed us to resolve small differences between modelers’ interpretations of the English language version of the algorithm. Second, it would have made it easier to use the model post study in adaptive management because it would have been much easier to modify the code. Finally, the argument that convinced people to use C++ during the study was the looping required to calculate non-wetland environmental performance indicators such as the northern pike model. In the end, the pike model meant it took more than an hour to run the IERM but the pike performance indicator did not help distinguish among plans. 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 such as David Klein of the Nature Conservancy 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 because the modeling process was very public and the model results were used directly in activities that stakeholders and decision makers took part in.

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 four teams would meet every few months to share successes and challenges; they were competitive but they were part of PFEG and ultimately wanted to see a great alternative produced more than they wanted the alterative from their team to be the best of a mediocre lot. Each team’s model 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.

While there were four primary formulators, several more PFEG members had the model suite on their (personal?) computers and used it to evaluate models and to check the evaluations other people had done. This work was done methodically and on an ad hoc basis. As an example of the former, a non-formulator might question the results of a formulator and re-run the evaluation checking that all the agreed conditions (for example, was the FEPS model set to use the agreed application of the wave data, did the formulator use the recent revision to Plan 1958DD to define the baseline) were being honored. 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 101 years. 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 evaluations produced economic benefits as traditionally calculated for navigation (shipping cost changes); coastal (changes in expected damages); recreational boating (changes in the value of recreation-day values); hydropower (changes in the value of energy at marginal market based rates) and municipal and industrial water (changes in operating costs). The environmental impacts of each plan were calculated as the ratio of the score achieved by an alternative for a particular parameter to the score achieved under the current regulation plan (in Corps parlance, the "without project" condition). For example, the wetland model produced the acres of meadow marsh present each year after a specifically defined low water supply condition. Those acreages were averaged over the entire 101 year run for each alternative and then divided by the number of acres produced by Plan 1958DD, the baseline plan. In addition to the performance indicators, statistics on over one hundred stakeholder designed "hydrologic attributes" was calculated for each plan and displayed automatically in the Board Room in both central locations with each or all attributes, and in "Interest" corners designed based on focus group like meetings with several stakeholder groups, For example, the navigation industry had a place in the Board Room with graphic comparisons they helped design of the hydrologic attributes they said they would use in deciding which plans were their favorites.

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.

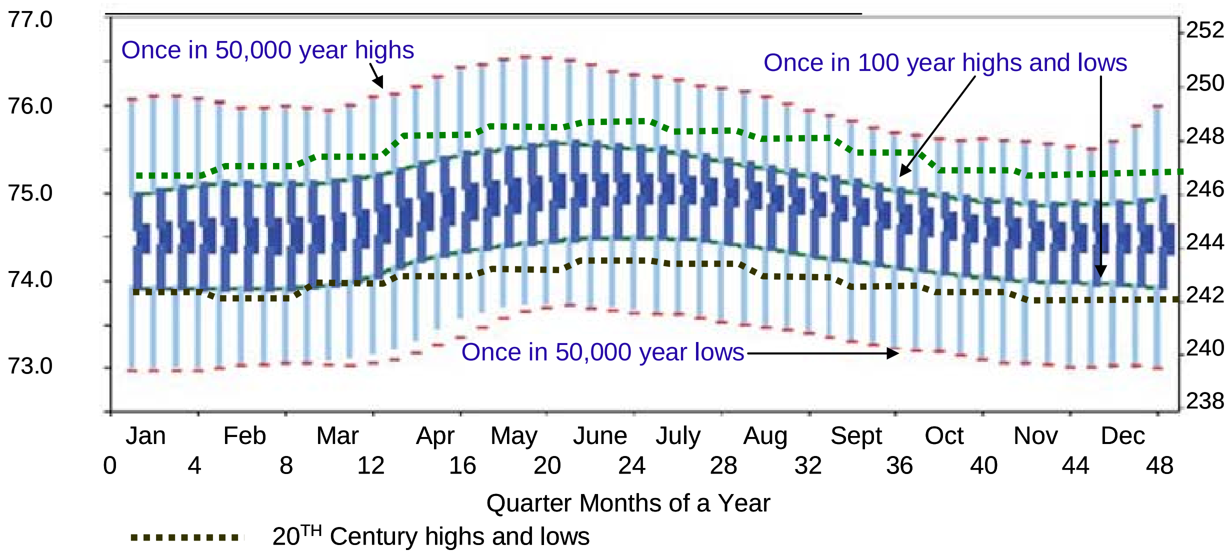


Figure 2. Range of possible Lake Ontario levels through the year under the current regulation rules

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 all the plans that met the Study Board requirements, A+ maximized economic benefits, B+ maximized environmental benefits, and D+ minimized sectoral losses. All three plans created millions of dollars per year in net economic benefits, but Plan B+ created more positive and more negative benefits. The implementation costs for any of the plans will be relatively small, with all plans about the same, so no benefit-cost ratio was calculated, 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 of 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. For example, reviewers asked why we had not used a hydraulic model to calculate water levels in the river rather than the regressed stage-discharge curves, and why we did not apply an uncertainty distribution to each element in the stage calculation so that a Monte Carlo analysis could calculate the probability distribution around the estimated stage which could then be applied probabilistically to stage damage curves. These were questions that had been addressed by the study's hydraulic engineers before the methods we used were selected. The relationship between the release decision and subsequent elevations in the St. Lawrence River was quite complex, dependent on channel roughness, tributary inflows below the dam, tides and wind. Yet the hydraulic engineers had forty years of data to base their regressions on, and could vary those assumptions in a Monte Carlo like manner in the stochastic simulation over 50,000 years, which varied not just the releases but the roughness factors and tributary flows. We were also able to compare our results to forty years of actual results – we were not building anything, so there was no need to speculate how these things would interplay together as there would be had we been channelizing or building levees. But the study team did not expect the review team to be as interested I the hydraulics as the peer reviewers were, and had not prepared a justification for their methods (although they had had to defend the methods before the Study Board, outside consultants and stakeholders before getting funding. The peer reviewers made their comments without discussing the issue with the study team and without any document that would allay their concerns. 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 based on the flawed FEPS evaluations but were not when properly evaluated. 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
Eldordo Irrigation District

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.

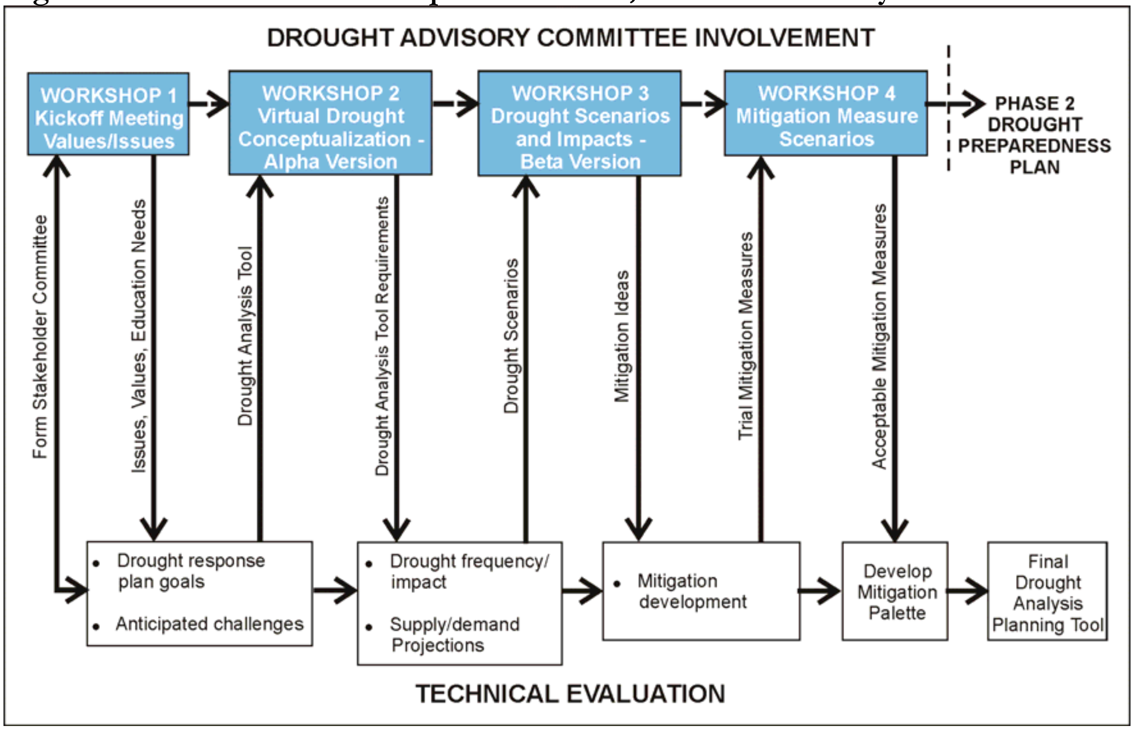
Shared Vision Planning – using diverse views to strengthen the whole

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

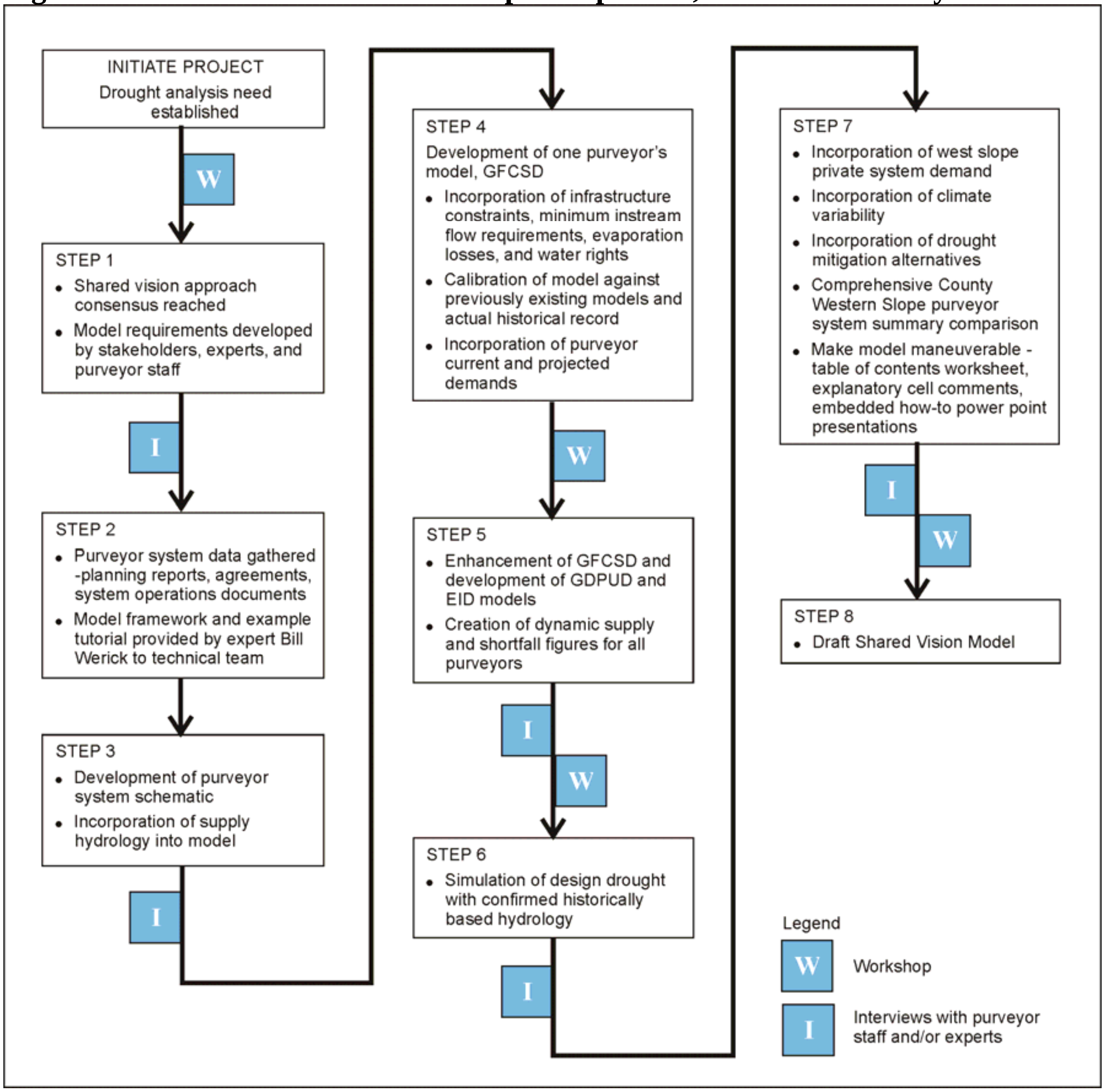


The key to acceptance by the diverse interest groups was an iterative, interactive process of data presentation, discussion of the data, sharing of personal experiences and rigorous scientific perspectives provided by several key experts. Having a stable of solid, well respected, nationally recognized 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.

<u>Notes from the Presentation</u>:
The following provides additional information covered during the presentation and through audience questions.

Description of the Shared Vision Model:

The data loaded into the model was depicted in a dashboard graphic using green, yellow and red indicator "lights" to indicate if the activity was within acceptable levels of performance – indicated by green; whether a measurement indicated a level of concern regarding performance – yellow; or whether the measurement was in the red zone – requiring immediate action. Data being monitored included such things as: flows in the American River, storage levels in Jenkinson Lake, levels in various storage basins, pressure levels in the distribution system, and a variety of regulatory measurements required as part of the hydroelectric plant operating license.

Explanation of the Shared Vision Development Process (Figure 1):

The primary forcing functions in this model involves communication, facilitation, and identifying and developing consensus on the data, the analytical tools used to assess the trends from the data, description of drought preparedness tools, identification of potential levels of drought based on historical and predictive trends, and potential actions that might be taken to reduce vulnerabilities of drought, plus potential response actions to augment the preventive measures.

Explanation of the Shared Vision Model Development Process (Figure 2):

The "W" and "I" indicators in the model depict the key forms of communication and facilitation occurring with the project. At times there was a need for a full participant level workshop – where all the stakeholders participating on the Drought Advisory Committee received information, discussed it, engaged in a facilitated two-way dialog to reach consensus. Other times it was necessary to interview stakeholder participants one-on-one to identify where a key point of conflict may exist in order to develop alternative approaches to resolve the dispute. Other times the use of caucuses or small groups would be used in an interview style, to better understand a particular interest or view point, as a way to develop alternative dispute opportunities and dialogs.

Q: Who were your stakeholders that the "expert team" led through the process?

A: The stakeholders included local agricultural growers, rafting/water recreational interests, land developers, community interest groups, environmental groups, Chambers of Commerce, local planners, former elected and appointed officials, Resource Conservation District members, County Agricultural Council, former state hydrologist, climatologist, former US Forest Service District Administrator, and general public members.

Q: Please clarify who comprised the "Drought Advisory Committee," the "Expert Team," and the "Stakeholders." What roles did they play, and how did these groups interact?

A: The drought advisory committee was comprised of the stakeholders. The experts gave presentations at each of the workshops, served as facilitators and assisted the group identifying the problems, potential solutions and priorities for actions. Sometimes the participants represented their technical area of expertise, other times they served as facilitators and small group leaders to ensure the various stakeholder comments were voiced and understood. The people that participated in the virtual drought simulations including the stakeholder drought advisory committee members, elected officials from El Dorado Irrigation District, County Board of Supervisors, County Water Agency, Grizzly Flats Community Service District, Georgetown Divide Water District, staff from each of the agencies, and the drought /model experts.

Q: Was the model developed beforehand or with the stakeholders?
A: The model was developed full on with the participants at the table. Once parameters were agreed upon they would be implemented at the next meeting to ensure there was still agreement.

Q: How long did the whole process take?
A: The process of working with the stakeholders, developing the model and reaching consensus on the model and its inputs occurred over a two year time frame. The reason for that length of time is because the process had to be vetted periodically with the elected boards of directors of three public agencies, based on their publicly noticed meeting schedules.

Q: Describe the outcomes of the process. What drought plans were developed? What things were learned? How was the model integrated into ongoing decision-making or planning activities, and did it change or influence decisions made during drought?
A: The results of the model were presented in a full participatory publicly noticed workshop in late October 2007. Each of the water entities are in the process of drafting implementing regulations to be adopted by the various elected boards of directors and county supervisors. Each of the agencies will adopt their own implementing regulations, as they have different jurisdictions, legal authorities and mandates.

Q: What role did the model play in developing consensus?
A: The model provided the shared framework upon which each of the legally constituted entities could develop their own regulatory and administrative procedures.

Panel Discussions*

Origins, Challenges and the Future: A Conversation with Early Innovators, Long Term Practitioners, and Clients of CADRe processes

Panelists: L. Bourget, R. Palmer, D. Sheer, and B. Werick

What are the Process Challenges of CADRe?

J. Delli Priscoli, D. Tate, D. Purkey, J. Lund

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

R. Miles, C. Peter, and S. Ponce

* Detailed summaries of the panel discussion are unavailable due to a recording malfunction.

Origins, Challenges and the Future: Early Innovators, Long Term Practitioners, and Clients of CADRe processes

Panelists:

Lisa Bourget, International Joint Commission
Richard Palmer, University of Washington
Dan Sheer, Hydrologics
Bill Werick, Institute for Water Resources, U.S. Army Corps of Engineers (Retired)

Moderators:

Leonard Shabman, Resources for the Future
Kurt Stephenson, Virginia Tech

Panel Discussion Summary Description:

This session brought together the early innovators (Palmer, Sheer, and Werick) 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. Lisa Bourget, Secretary of the U.S. Section of the International Joint Commission (a binational treaty organization responsible for addressing disputes primarily related to water and the environment along the Canada-U.S. border), provided the end-user's perspective on the value and challenges of what it is the panelists do.

The panelists emphasized the open-ended nature of CADRe process. Sheer described a CADRe process as being analogous to an unscripted play. The responsibility of the stage manager (the CADRe organizer) is to ensure that the correct props are in place (models) and all the players are there. He/she coordinates and encourages the players, but has no control or authority over the unfolding play nor any preconceived notion how it will end.

The panelists also described different ways to build trust in the collaborative models. Building trust in the models was considered essential. Palmer emphasized that group model construction from the "ground up" has been an important element of successes he has had but acknowledged that very complex models with less transparency can work if the negotiating parties trust the modeler.

The panelists shared experiences and processes to productively manage conflict and emotion. Panelists emphasized the importance of early involvement in the decision-making process and creatively identifying meaningful performance metrics. When participants shift their focus away from conflict with other parties to a focus on trying to "beat" the model so everyone can win, negotiation becomes easier. Building a sense of community through humor and informal social interaction was also stressed.

The CADRe practitioners acknowledged that future CADRe processes would benefit from the expertise of professional mediators, perhaps in partnership with a modeler. However, Bourget noted that in these early innovators, the skills of mediator, modeler, and stage manager are embodied in one person.

What are the Process Challenges of CADRe?

Panelists:
Jerry Delli Priscoli, Institute for Water Resources, U.S. Army Corps of Engineers
Diane Tate, CDR
David Purkey, Stockholm Environment Institute
Jay Lund, University of California, Davis

Moderator:
Jim Creighton, Creighton and Creighton, Inc

Panel Discussion Summary Description:

The panel consisted of two professionals with principle expertise in facilitation and mediation and two professionals with principle expertise in technical water resource modeling. Jerry Delli Priscoli is a world-renowned facilitator of water resources forums and has worked with the World Bank, UNESCO, WHO, and other organizations on multilateral negotiations concerning water resources. Diane Tate is a Program Manager at CDR Associates, an internationally recognized organization of conflict resolution specialists headquartered in Colorado. Jay Lund is a Professor of Civil and Environmental Engineering at the University of California, Davis with extensive expertise and policy experiences in water resources modeling. David Purkey is the Director of the Water Resources Group of the Stockholm Environment Institute-US Center and is responsible for all hydrological assessment and modeling work conducted by the Institute.

The panel highlighted integration challenges and opportunities. Modelers and mediators asked each other questions about the aspects of the CADRe process including ideas on how to build legitimacy in collaborative processes and not just legitimacy in technical models. The panel emphasized transparency and active, full engagement, but noted that this cannot guarantee success. Panelists discussed when and how moderators can work cooperatively with modelers to make technical models more participatory and accessible. Panelists also discussed how stakeholder participation can be increased, how models may need to be of high resolution to effectively serve as a focal point for a negotiation, how flaws in the stakeholder processes can undermine the credibility of technical analysis, and how the challenge of participants who use their credentials as scientists to advocate for particular outcomes. One theme that emerged was that those who are authorized to “make decisions” should make it clear that they accept the CADRe process as a useful and significant decision making forum.

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

Panelists:

Rick Miles, Federal Energy Regulatory Commission
Chandler Peter, U.S. Army Corps of Engineers, Omaha District
Stan Ponce, U.S. Geological Survey

Moderator:

Kirk Emerson, U.S. Institute for Environmental Conflict Resolution

Panel Discussion Summary Description:

This panel gathered representatives of federal agencies to identify and discuss how agency missions and decision practices create both opportunities and challenges to using CADRe processes. The panelists had over 80 collective years of experience working within federal agencies on multiple water resource issues. Rick Miles began his career with FERC working on hydropower licensing issues and currently serves as FERC's Director of Dispute Resolution. Miles has also served as chair of the Interagency Alternative Dispute Resolution Group Steering Committee. Chandler Peter is currently responsible for directing Section 404 Permitting and NEPA analysis of several major water supply and infrastructure development activities for the Corps of Engineers in the Rocky Mountain and Great Plains regions. Stan Ponce provided perspectives from his experiences working in several agencies, including USGS, Bureau of Reclamation, National Park Service, and U.S.D.A. Forest Service. Ponce's experience with the Department of Interior suggested that CADRe processes can be important, but will depend on the circumstances of each situation and the nature of the agency program. The Section 404 permitting system especially illustrates how features unique to a particular agency program and its implementing regulations can create barriers to incorporating CADRe-like processes. Miles explained how FERC has successfully reformed their hydropower licensing process by moving to a structured collaborative negotiation process that places more responsibility on deciding license conditions from FERC to the licensee and interested stakeholders. Such processes are consistent with and could be facilitated with CADRe-like processes.

Open Space Sessions: Summary Reports

The focal point of the workshop was the identification of, and dialogue on, particular themes that need to be addressed in order for CADRe to be more widely and effectively employed in water resource decision-making contexts. Drawing upon the presentations and dialogue from the previous sessions, participants identified issues, concerns, and opportunities, which were consolidated into six themes. Participants self-organized into breakout groups to discuss these themes and then shared the results in a final plenary forum.

The six themes that were identified are:

1. Modeling Software and Web Tools Available and Needed
2. Training and Education for CADRe
3. Integration of CADRe in NEPA
4. Neutrality and objectivity in CADRe processes
5. CADRe Community Development (the “Wiki Session”)
6. Research Agenda for CADRe

This section contains summaries of the discussions for each open space group.

Modeling Software Group

Participants: Chris Dunn, Beaudry Koch, Rich Juricich, Jesse Roach, and Alexey Voinov (convener)

Some of the main features of models and software that are to serve the Shared Vision Planning (SVP) process were discussed.[1] SVP models are used to build trust. This is their major utility in the process. As such models need to be:

- Transparent. Not just models themselves should be easy to understand, but they should be instrumental in increasing the transparency of the whole process: the corps does not get sued because of function, but because of process.
- Modularity. Models should provide ways to be coupled and linked to other models and tools. Plug and play.
- Software should guide through the process, suggesting what the next step should be. Expert systems.
- SVP requires models that go beyond water resources. Obvious other areas to cover: water quality models, economic models.
- Tiered approach. Hierarchies of models. No one model is appropriate for all cases, it is a problem driven process.
- Process should be open. This makes open source products most desirable. California guidelines already recommend open source.
- Process should live on the web.
- Data access. Data are also models and can be treated as a special case of a model. Therefore same principles apply.
- Visualization and interfaces.
- Means to formulate scenarios and feed them into models.

Areas of priority:

- Explore how available commercial products (Stella, Powersim) can be linked to more complex tools (OASIS? HEC models?)
- How to capture the important dynamics of complex models in simple ones
- OpenMI approach for model coupling. Already used in HEC
- How to embed spatial hierarchy - regions developing their own SVP processes, which then become a state plan.

SVP - is it actually decision support rather than dispute resolution?

Cultural shift is needed to allow other people to come into the modeling process.

[1] SVP is a specific application of CADRe developed by IWR

Education and Training in CADRe Group

Participants: Allyson Beall, Doug Clark, Tony Eberhardt, Herman Karl, Rick Miles, Rick Palmer, James "Ric" Richardson, Megan Wiley Rivera (convener), Len Shabman, Michael Sheer

Current Resources

Courses

Education and training in some areas of CADRe is already underway. Rick Palmer has been teaching a course in Shared Vision Planning for a number of years, and all of his course materials are available online (http://www.ce.washington.edu/%7Epalmer/CEE576.htm). This course has also been adapted to trainings for professionals. We hope to collect links to other pertinent courses on the CADRe Wiki as a resource for faculty and students.

Programs

In our group alone, three CADRe-related programs were represented: the MIT-USGS Science Impact Collaborative (MUSIC) (http://web.mit.edu/dusp/epp/music/), the Community & Regional Planning Program at the University of New Mexico (http://www.unm.edu/~crp/), and the Program on the Environment - Environmental Management Certificate Program at the University of Washington (http://depts.washington.edu/poeweb/gradprograms/envmgt/index.html).

Guidance

At the undergraduate level in particular, many students with a developing interest in CADRe find themselves piecing together a curriculum to prepare them for practice and/or future study. To aid these students and others, we suggest including a list of practioners, faculty, and students who are willing to provide guidance on the Wiki. We learned in discussion that some faculty already provide this service.

Case Studies

A bibliography of case studies is currently available on the SVP website (http://www.sharedvisionplanning.us/) and case studies with models can also be obtained from HydroLogics (http://hydrologics.net/).

Needs and Challenges

The needs and challenges to providing effective education and training in CADRe to the people who want and need it are great, and our discussion only touched on some of them. The cross-disciplinary nature and nascent stage of CADRe as a field in particular create educational challenges at all levels. Some specific examples are summarized below.

Professional Education

The group voiced a need for practicing engineers and computer modelers who are or will be involved in CADRe processes to gain the skills needed to facilitate or at least participate productively in such sessions. Such training might be designed for engineers who don't naturally have some of the characteristics of historically-successful CADRe modelers but who want to contribute to the process. For this group, short, virtual courses through professional organizations such as ASCE were deemed the most appropriate venue.

Undergraduate Education

The discussion of these "CADRe-challenged" engineers raised a tangential issue: could exposure to CADRe as a field help attract and retain "CADRe-friendly" people to engineering? There is evidence that some students with an interest and aptitude for STEM (Science, Technology, Engineering, Mathematics) fields leave them if they develop the impression at the high school or undergraduate level that these fields are isolating and do not provide opportunities to help people or better the world.[2]

There are also likely to be benefits to society at large of including well-executed CADRe courses at the undergraduate level. Arming the next generation with the ability to utilize scientific knowledge and technological tools, function effectively on interdisciplinary teams, and successfully negotiate with disparate interests can only enhance society in both foreseeable and unexpected ways— training policy-makers who understand the potential of cutting-edge science and technological tools to inform decision-making, lawyers who have a new model for negotiations of long-standing disputes, scientists who can design studies to focus on pressing societal issues.

However, if the primary goal of CADRe training and education is to better-prepare individuals who will actually practice CADRe, putting resources into the undergraduate level provides a low return on the investment when compared to working with students at the graduate level who are already interested in this area of study. In addition, in-depth training in at least one CADRe area is desirable, so exposure to CADRe should not come at the expense of a solid foundation in a specific discipline.

Graduate Education

For established graduate programs in CADRe-related areas, finding internships/apprenticeships was identified as one of the current challenges. During the discussion with the larger group, Hal Cardwell informed us that such opportunities are available at IWR. We hope the Wiki can be used to facilitate additional connections.

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[2] Margolis, J., Fisher, A. and Miller, F. (2000) The anatomy of interest: women in undergraduate computer science. *Women's Studies Quarterly*. 28(1/2), 104-127.

Seymour, E. and Hewitt, N.M. (1997) *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press.

The numerous challenges to establishing such programs include overcoming the “silo effect” present at most academic institutions, the additional workload for people who want to forge these relationships, and procuring the needed resources. In our group, we had examples of cases in which opportunities opened to develop radically new interdisciplinary programs (see examples above). In general, however, taking a course-by-course approach seemed more realistic to the group. We were pleased that two members of the discussion group were already planning to bring elements of CADRe into their courses.

Action Items

Based on the above needs and challenges, a list of action items was developed:

- Use the Wiki as a common information source for materials, programs, course information, contacts, and internships
- Create more internship opportunities for graduate students
- Develop and post a list of the desired skill set for CADRe practioners to guide students and others who wish to expand into this field
- Create a Best Practices Manual of CADRe techniques
- Expand SVP’s bibliography
- Develop training opportunities in cooperation with professional organizations
- Include CADRe in undergraduate courses as possible

Integrating CADRe into NEPA Group

Participants: Kirk Emerson, Mike Eng (convener), Michael Fies, Carly Jerla, Chandler Peter, and Diane Tate

- The Council on Environmental Quality (CEQ) will soon be issuing, "Collaboration in NEPA Handbook." It will include advice and guidance for lead agencies wishing to utilize voluntary collaborative tools and approaches in how it conducts NEPA processes.
    - Key questions for lead agency: With what entities do you wish to collaborate? To what extent do you wish to collaborate with these entities? At what steps in the NEPA process do you wish to collaborate with these entities?
    - USIECR has a role in promoting NEPA collaboration, in conducting outreach on NEPA Collaboration Handbook and in delivering NEPA collaboration training. USIECR will use these opportunities to encourage agencies to consider integrating CADRe into collaborative NEPA processes.
- CADRe would be an appropriate tool to consider utilizing when conducting collaborative NEPA processes
- Collaborative modeling steps (Problem Statement, Evaluation Metrics, Alternatives, Evaluation, Solution) are quite similar to NEPA steps and could be lined up nicely if pursing a integrated CADRe/NEPA process
- Opportunities and obstacles to using CADRe with NEPA processes for Sec. 404 Permits:
    - Need to ensure that required regulatory criteria are translated into clear performance measures for analyzing NEPA alternatives
    - Include CADRe capabilities in RFPs for NEPA contractors
- How can CADRe be used to speed up NEPA processes that need to be implemented as quickly as possible?
- Other challenges to using collaborative approaches to NEPA using CADRe:
    - Internal organizational resistance to collaboration
    - Difficulties in engaging other agencies to collaborate in the NEPA process

    - Leadership must be supportive of collaborative approach to NEPA and use of CADRe

- Situation assessments (conducted by third party neutrals if appropriate) are helpful in evaluating the feasibility of collaboration and the interest of other agencies in participating

Neutrality and Objectivity in CADRe Processes Group

Participants: Nina Burkardt, Mark Lorie (convener), Beth Richards, Len Shabman, Diane Tate

Our discussion focused on the issue of the neutrality of a CADRe facilitator/leader and what that means for the decision-making process within CADRe. The issue was somewhat nebulous when we began, and so we discussed a variety of topics related to stakeholder values and preferences and the subtle ways that a CADRe leader can influence how values and preferences are used in a decision process. A CADRe leader has to be impartial and unbiased so that there can be some level of objectivity in the decision-making process.

Eventually, this seems to boil down to two basic realities about CADRe and the context in which it is used. First, it is clear that CADRe is predominantly a *social and political process* and not a scientific process. The objective of a science process is generally to discover facts. The objective of a CADRe process is to arrive at informed conclusions about how a public resource should be managed given public preferences and values. But there is research to suggest that people's values and preferences are vague until they are confronted with decision problems (see writings by Paul Slovic and Robin Gregory). Therefore, the values and preferences that will guide decision-making actually take shape during the decision process. So the CADRe process is one of defining and framing an issue and negotiating to find solutions. And the CADRe leader can have significant influence over all of this.

Further, the fact that CADRe is fundamentally political should be accepted and respected by analysts, researchers, modelers and any other professionals involved with CADRe processes. Our society is governed by the political decision-making process and that is just how it is. We often hear analysts complain that "politics got in the way" of sound, science-based decision-making. That politics will influence or dominate environmental and natural resources decision-making is completely unavoidable. One might argue that it is, in fact, desirable that decisions are guided by public preferences as long as the role of science in decision making is understood. The fact that societal forces may shape values and preferences does not mean that CADRe facilitators cannot be impartial in their guidance of the process.

The second reality about how CADRe functions is that all people have prejudices and biases, including facilitators, modelers and those who try to combine those two roles in leading CADRe processes. All people have ideas about what is right and wrong, good and bad. And the professionals who might get involved with a CADRe process will have strong ideas and attitudes about how water should be managed and how those decisions should be made.

Accepting these two realities about CADRe seems to change the way we think about neutrality, impartiality and objectivity. In a science process, these issues are dealt with by adherence to the scientific method (so research can be replicated), by relying on measurable outcomes (so that biases are minimized), and through the peer review process (so results can be checked and verified). In CADRe, values and preferences are key factors, but they are often vague and unmeasurable. The CADRe leader facilitates the process of defining the key values and preferences. Since the person leading the process has significant influence and unavoidable biases, CADRe must incorporate a different set of principles to ensure neutrality and objectivity. The discussion highlighted a few themes on what these principles might be.

First, it is crucial that a broad cross-section of stakeholders be involved in a CADRe process. Any stakeholder who can influence the decision should be involved. This can lessen the chance that someone will work outside the CADRe process to influence the decision. Broad representation of stakeholders can also be thought of as peer review for the process of framing the problem and defining value and preferences. Adequate representation of stakeholders ensures that all important segments of the public are involved and therefore the associated values and preferences will be incorporated. Further, it is important that effective representatives of stakeholders be involved—they must have some influence, they should be able to communicate well etc. Having a broad range of stakeholders means that they can serve to balance each other and the potential biases of the CADRe leader. The nature of stakeholder involvement and the techniques used is also crucially important, but that was discussed less

A second principle that was discussed in order to ensure neutrality and objectivity for CADRe was transparency. There are two levels of transparency. *Internal transparency* refers to the CADRe leaders being transparent (honest) with themselves. This is a necessary precondition in order for them to be honest with other participants about their own biases etc. *External transparency* refers to the degree to which the process is open and understandable to all participants. It includes the CADRe being honest and open. It also includes the methods by which intermediate decisions are made (such as about data collection, modeling techniques). In addition, the ability of stakeholders to access models, data and information is also a part of external transparency.

None of this is new ground for most people involved with CADRe. But these issues are still important for two reasons. One, these issues are insufficiently researched and articulated for the CADRe community. . Much can be learned from other fields such as planning theory, decision analysis, political sciences, and dispute resolution. But there needs to be research and guidance on what these topics mean specifically for CADRe. The second reason they are important is that many people who are involved with CADRe processes are not really part of the CADRe community. People who are primarily scientists, modelers, analysts, or administrators probably have not thought about these issues. And the notion that decision-making can be the same as a scientific process is often deeply engrained in people's minds, making it difficult to address the issues described above in a CADRe process. More research, more writing and guidance, and more outreach will help.

There are many topics related to this discussion that need more research and synthesis of existing research. Here are a few:

1. How are values and preferences formed in CADRe and what does this mean for how CADRe processes should be designed and managed?
2. What techniques should a CADRe rely on to demonstrate internal transparency and ensure external transparency?
3. What do these issues of neutrality and objectivity mean for the models used in CADRe? How is this different from principles of modeling that apply to scientific/research processes?

Themes along these lines should be included in the CADRe research agenda.

CADRe Community Development: the “Wiki” Group

Participants: Lisa C. Bourget, James L. Creighton, Ane D. Deister, Eric Hagen, Jordan Henk, Stacy Langsdale, Tarla Rai Peterson, Jerry Delli Priscoli, Vince Tidwell, Dan Rodrigo, Kurt Stephenson, Jessica Thompson, Bill Werick (convener)

In 2 months:

- Proceedings
- An edition of Jerry’s journal announcing the wiki
- A report on the “church” and the site
- A name for the collection of professionals we are
- A mailing list with organizations listed for each name
- Ideas for the next meeting of the clan
- A presentation at the next World Water Council? International Water Association?
- Outreach to other conferences (ASCE, AWRA) to let them know we exist
- A Business Plan for the wiki/church

Elements of the Wiki:

- Papers
- List serve questions
- Primers (1 page, 5 page, a manual of practice, guidelines to practice)
- Bill Werick temporary editor-in-chief
- Editorial Board restricts input
- Free comment space
- Story of the day drawn at random
- Map of the world showing where shared vision planning is being done
- Examples of clever visualizations used to improve understanding, communication
- Short (U-Tube) videos by practitioners
- A “model” corner for software, completed models
- A Glossary
- Links to other professional societies

Wiki users would include practitioners, academia (could be used to develop undergraduate or masters classes). Student input could make site more inviting. National contests?

Research Agenda for CADRe Group

Participants: Hal Cardwell (chair), Tom Lowry, Marissa Reno, Suzanne Pierce, Paul Kirshen, others

Current research areas:

- Development of performance measures to assess the benefits of doing CADRe over alternative approaches. (IWR is starting a small scale study to generate performance measures to measure aspects such as learning, impacts on process and decision, value of model, change in social capital)

Ideas for potential research areas:

- Identify both obstacles and incentives to implementation of CADRe through a review of case studies.
- Development of standard processes or principles/best practices. This should be done by a team of about ten experienced users and advocates through synthesizing a significant number of completed case studies.
- Identify if certain tools are best suited to particular client agencies or user groups and why. This can be based on existing case studies. The goal would be to produce guidelines for tool selection according to the target audience.
- Initiate research-focused case studies – well-designed in coordination with other disciplines, trying multiple methods and evaluation using interdisciplinary teams. A focus could be on re-operation existing infrastructure.
- Seek and identify any technological improvements and physical science tools which could support or improve CADRe (for example: visualization tools). How can we bring these tools into CADRe and continue to keep CADRe tools at pace with technological advances?
- Characterize the interface between CADRe and Integrated Water Resources Management (IWRM) and how each field can inform the other.
- How can we best engage marginalized stakeholder groups such as Tribes? Process professionals at USIECR may have resources on this.

Other overall goals that were discussed in the research agenda include the need to ingrain social science and other disciplines into water resource planning and management processes, yet continue to support hard science research – e.g. forecasting and applied uncertainty analysis for improved operation. Any priority list of research needs also will need to included research needs identified in the Modeling, NEPA & CADRe, and the Neutrality breakout groups. These should be consolidated with this list.

Post Conference Contributions

Shared Vision Planning for the North Branch Potomac River
M. Lorie and E. Hagen

A Federal Research Initiative on CADRe?
SWAQ Interagengy Working Group

CADRe Workshop Reflections
Jim Creighton
Jerome Delli Priscoli
Tony Eberhardt
Erik Hagen
Beaudry Kock
Jesse Roach
Jessica Thompson

Shared Vision Planning for the North Branch Potomac River

Mark Lorie and **Erik Hagen**
Interstate Commission on the Potomac River Basin

Introduction

Shared Vision Planning (SVP) is one approach to Computer Aided Dispute Resolution. SVP combines three common practices to solve difficult water resources problems: 1) a traditional planning technique, 2) structured stakeholder participation, and 3) systems computer modeling. These three practices are combined in SVP in order to make the planning and modeling processes more transparent and reflective of stakeholder objectives, while introducing technical rigor the stakeholder participation process. The aim is to produce a *shared vision* of how a water resources system works, so that stakeholders and managers can have a productive debate about how the system should be managed.

SVP traces its roots to water supply management for the Washington, D.C. region. Nearly 30 years ago, researchers from The Johns Hopkins University and the Interstate Commission on the Potomac River Basin (ICPRB) helped resolve a dispute among the three major D.C. area utilities—the Washington Suburban Sanitary Commission, the Washington Aqueduct Division of the Army Corps of Engineers, and Fairfax Water—by using computer models to facilitate learning and negotiation (see Sheer, 1983). That work led directly to the Water Supply Coordination Agreement of 1982, which, among other things, established the ICPRB Section for Cooperative Operations on the Potomac (CO-OP). CO-OP serves as the administrative and technical lead for the utilities' coordinated system of water supply planning and operations. The work that resulted in the Water Supply Coordination Agreement and CO-OP was the starting point for several researchers to further develop SVP and similar techniques.

Since then, CO-OP has been working with the D.C. area utilities to conduct long-term water supply planning and reservoir management during times of drought. Two of the Potomac reservoirs that are used to ensure a reliable water supply for the D.C. region serve and impact other purposes as well. ICPRB requests releases from these reservoirs during times of extreme low flow on the Lower Potomac. In addition to water supply augmentation releases, the U.S. Army Corps of Engineers (the Corps) operates these reservoirs to enhance water quality on the North Branch of the Potomac River and to support recreational activities on the reservoirs and in the rivers downstream. Socio-economic and environmental conditions within the Potomac basin have changed considerably since the early 1980s, when the current management plan was developed: acid mine drainage problems have largely been mitigated, treatment of industrial wastewater has improved, recreational industries have flourished and many cities and communities have been growing rapidly. Resource management agencies and stakeholders have been working to address these new challenges for reservoir management.

This case study report will summarize the research and negotiations that led to the current system of coordinated water supply management for the D.C. region and how that work led to the development of Shared Vision Planning and similar approaches. Because of the legacy of coordination and cooperation with the CO-OP system, ICPRB is well placed to lead a new phase of cooperative management of Potomac basin water resources. ICPRB is working with stakeholders and resource agencies to conduct a Shared Vision study of reservoir operations on the North Branch. This report will describe the context for this new Shared Vision study, including the stakeholders, reservoir management[1] problems and objectives, technical issues, and ICPRB's plan for executing the study.

Background

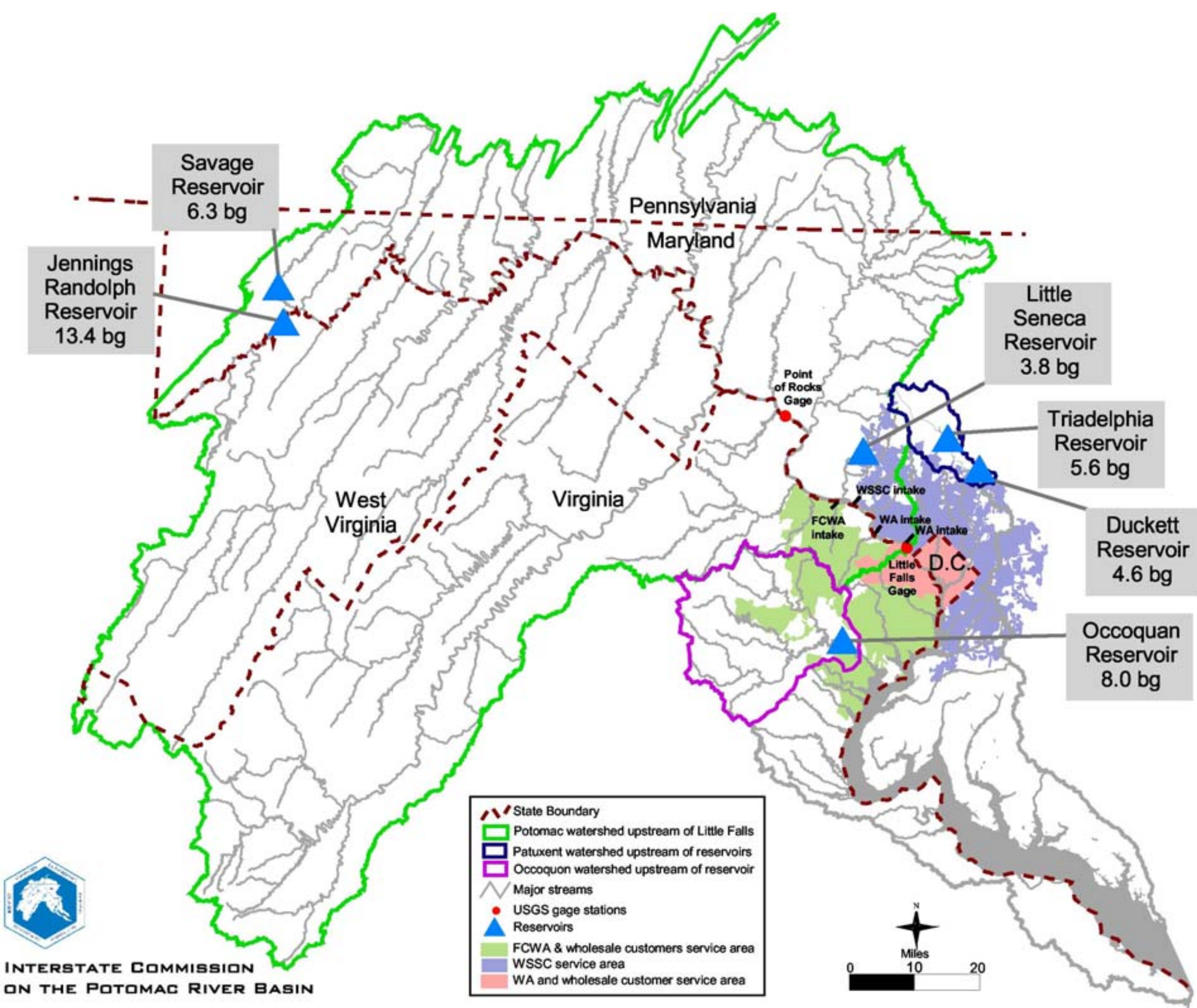
The North Branch region of Potomac River Basin includes two major multi-purpose reservoirs (see figure 1). Savage Reservoir and Jennings Randolph Reservoir (collectively known as the North Branch reservoirs) are located above Luke, MD. Savage Reservoir is owned by the Upper Potomac River Commission (UPRC) and Jennings Randolph is owned by the Corps. The North Branch reservoirs are operated for three primary purposes: flood control, water quality enhancement and water supply for the D.C. region. The 123,000 acre-feet of Storage in Jennings Randolph is formally allocated to one of these three purposes: 28% for flood control, 39% for water quality and 33% for D.C. water supply. These three segments of storage are operated separately: ICPRB requests releases from water supply storage on behalf of the CO-OP utilities, while the Corps operates water quality and flood control storage. Savage Reservoir is generally operated in coordination with Jennings Randolph but it does not have official storage allocations. To the degree possible, these reservoirs are also managed to provide whitewater boating and fishing opportunities downstream, along with boating and beach access on Jennings Randolph itself.

The Corps manages the flood control and water quality storage in Jennings Randolph reservoir, and all the storage in Savage Reservoir. The water quality storage is used to augment summer low flows in order to promote better water quality in the North Branch downstream. Two of the primary water quality stressors are sediments from Georges Creek (resulting from acid mine drainage treatment) and treated industrial effluent from a paper mill in Luke, Maryland. The Corps stores water from high flows in the Spring and releases that water throughout the Summer and Fall low flow period. In addition to augmenting low flows, the Corps manages the reservoirs for on-lake and downstream recreation. In general, releases from Savage Reservoir are coordinated with releases from Jennings Randolph: the typical ratio of Jennings Randolph to Savage Reservoir releases is 4 to 1. Usually, the Corps makes whitewater recreation releases from Jennings Randolph in the spring and from Savage Reservoir in the summer.

[1] Note: For this discussion the term "reservoir management" will be used generically to represent the general procedures used to determine reservoir releases given storage and flow objectives.

As noted above, the three major Washington, D.C. area water suppliers rely on the North Branch reservoirs and Little Seneca to ensure a reliable water supply. Most of the water used by these utilities comes from the Potomac River (about 75%), while the rest comes from the Patuxent and Occoquan reservoirs (see Figure 1). When Potomac River flow is very low, releases from upstream reservoirs are needed to ensure that the utilities can continue withdrawing needed water while still allowing for a minimum flow-by of 100 million gallons per day (MGD). During drought conditions, CO-OP makes forecasts of flow and demand up to nine days into the future. When these forecasts suggest that flow will be insufficient to meet demand plus the required flow-by, CO-OP requests releases from Jennings Randolph and/or Little Seneca Reservoirs. Water supply augmentation releases have been made in only two years (1999 and 2002) since this system was put in place in 1982. The basic strategy for managing this system were developed as part of the original study that led to the Water Supply Coordination Agreement.

Figure 1: The Potomac River Basin and Reservoirs



The Roots of Shared Vision Planning

Severe droughts in the 1960s left the three D.C. area utilities wondering about the reliability of their water supply. The Potomac hit it's record low flow of less than 400 MGD in September 1966. Between 1971 and 1982, the total demand of the D.C. area utilities exceeded 400 MGD 41 times (Mays, 1983), and the region was projected to continue growing rapidly. The Corps of Engineers proposed up to 16 new multi-purpose reservoirs to help secure a reliable water supply. These reservoirs would have dramatically changed the character of the Potomac River and so the plan was met with considerable public opposition. A stalemate would have left the region increasingly vulnerable to water shortages during droughts.

Researchers from The Johns Hopkins University and ICPRB discovered through simulation and optimization that the utilities could shore up their water supply reliability with merely 2 new reservoirs (one of which was already being constructed by the Corps) *if* they were willing coordinate their operations. If the utilities could coordinate their withdrawals from the Potomac and their use of off-Potomac reservoirs, they could realize a system yield greater than the sum of the yields of the individual components. In other words, coordination would create efficiencies that could reduce the need for new reservoirs. This coordinated approach would be at less cost and with less environmental impacts (Sheer, 1983).

The utilities were not immediately on board with this idea. Published modeling results were not enough to convince them. At the time, utilities were not accustomed to this kind of cooperation and securing water through operational strategies rather than construction of new resources was a novel idea (Sheer, 1983). In order to promote the coordinated approach, researchers used their computer models in gaming exercises with utility water managers. The utility representatives were given the opportunity to interact with models, review the assumptions and algorithms, and test operational ideas with immediate feedback. In essence, the researchers were trying to make the models transparent and believable. The strategy worked and resulted in a series of agreements that set up an innovative cooperative system of water supply management. This system saved money, prevented significant environmental impacts, provided a reliable supply of water to nearly 4 million people through two droughts (1999 and 2002), and is expected to be robust for the foreseeable future. The lead researchers for this pioneering work went on to further develop their collaborative modeling techniques, eventually establishing Shared Vision Planning and Computer-Aided Negotiation as accepted CADRe techniques.

Challenges and Opportunities

The current reservoir regulation plan for flood control and water quality storage in Jennings Randolph was originally developed in the late 1970s and revised in 1985. Several factors have changed significantly since that time. In the early 1980s, the North Branch Potomac River had severe acid mine drainage problems, but these problem have largely mitigated. One of the primary water quality objectives for the water quality storage in Jennings Randolph was to improve pH. Now that acid mine drainage problems have been mitigated, pH is much less of a concern. Other water quality issues have come to the fore, such as temperature and sediments. The Corps has adjusted its operations to reflect these changes but it is possible that more can be done.

As water quality has improved in the North Branch, a substantial recreational fishing industry has developed. Anglers can find both cold water and warm water species within the North Branch, along with a highly prized cold water fishery in the Savage River below the reservoir. Both rivers attract individual fishermen and support several commercial guiding businesses in the area. The condition of the fishery and recreational fishing opportunities are affected by reservoir operations in numerous ways. The reservoirs have significant impacts on water quality, especially temperature, but also sediments and other factors, and these water quality conditions affect the conditions of the fishery by affecting fish habitat, fish behavior, and access for float and wade fishermen. These impacts are widely known but not sufficiently understood or quantified.

Whitewater boating is the focus of another significant recreational interest within the North Branch region. The Savage River below the reservoir is a highly valued whitewater river and has been used to host both the World Championships and Olympic trials in the past. The North Branch above Luke, Maryland is not as technical as the Savage, but it does attract a number of kayakers when flows are sufficient. Both rivers attract individual kayakers and help support several commercial guiding businesses. The Corps has been making whitewater releases to allow for kayaking and rafting for several years. In general, whitewater releases are made from Jennings Randolph up to four times in the spring, and from Savage Reservoir up to two or three times in the summer. Kayaking as a recreational activity continues to grow and, along with recreational fishing, is seen as a source of economic development for the region.

There is also a substantial amount of recreation on Jennings Randolph Reservoir. There are boat ramps on both the West Virginia and Maryland sides, and there is a beach on the West Virginia side. The facility also includes a campground. Thousands of visitors go to Jennings Randolph each year and the visitation rates appear to be growing. Water levels in the reservoir drop through the summer in most years. When the water level gets low enough, the beach and one of the boat ramps have to be closed. The Corps considers the water levels that will affect shore access when deciding how much water to release from water quality storage.

Water supply and consumptive use within the Potomac basin are significant demands as well. The D.C. region continues to grow rapidly. The latest water supply reliability report from ICPRB (2005) concludes that there is little risk of shortages over the next 25 years. However, the region continues to grow rapidly and climate change impacts introduce more uncertainties and potential risks. In addition, other communities upstream of Washington are also growing. ICPRB (2000) showed that consumptive use within the basin will grow by as much as 30 MGD by 2030 (compared to 2000 consumptive use levels).

In the background for all these changing issues are the legislative and regulatory constraints for the reservoirs. Some of these constraints are clear and quite binding, while others are less so. For example, absolute minimum allowable releases and preferred minimum releases for both Jennings Randolph and Savage Reservoirs are clearly established in authorizing legislation and Corps policy. In addition, the NPDES permit for the wastewater treatment plant in Westernport, Maryland (which treats industrial effluent from a paper mill, along with municipal waste from area towns) is based on an expected low flow (the 7Q10, or seven day low flow expected to occur once in ten years). The 7Q10 depends significantly on how the reservoirs are operated. Over and above these issues, the Corps is mandated to manage the reservoir in certain ways. Water quality, water supply and flood control are the top priorities, while recreation was added a secondary purpose in subsequent legislation.

Addressing the New Challenges

In 2005, stakeholders and resource agencies formed the North Branch Advisory Group (referred to as the "Group"). The Group consists of local whitewater and fishing guides, vocal individual boaters and fishermen, and representatives from state resource agencies. The purpose of the Group was to discuss reservoir management objectives and provide recommendations to the Corps on reservoir release schedules that could address the Group's proposed objectives. The Group focused primarily on recreation (boating and fishing) and fish habitat issues. The Corps attended the Group's meetings and participated in the discussions. After nearly two years of quarterly meetings, the Group agreed on a set of general objectives for reservoir management. In addition, the Group developed some recommendations for releases (both the magnitude and timing) that could help achieve their objectives, though there was less agreement on these recommendations than on the objectives.

The North Branch Advisory Group began to finalize their recommendations as a dry spell developed in the Potomac basin during the Spring and early Summer of this year. Recent rainfall, reservoir levels and flows were well below average by the end of June, when a whitewater release was scheduled for Savage Reservoir. There was some question whether the whitewater release could be made and leave enough water to support fish habitat through the remainder of the summer, especially since a drought was taking hold. The question generated some controversy and it became clear that more work was needed to determine the extent to which the reservoirs could meet the recreation and fisheries objectives, without increased risk for higher priority purposes and under a range of hydrologic conditions.

Shared Vision Planning for the North Branch

Because of the controversy generated by the drought conditions in the summer of this year, ICPRB proposed a SVP study to the North Branch Advisory Group. The Group was receptive to the idea and work on the Shared Vision effort began immediately. This section will describe the players, ICPRB's plan and work accomplished so far.

Study Objective

ICPRB's goal in this study is to develop and see implemented a new reservoir management plan for Jennings Randolph and Savage. There may be limits to the changes that can be made, but the goal is to develop a plan that will promote improvements to water quality, fisheries health and habitat, recreation, and water supply reliability for the CO-OP system and other areas.

Decision-Makers and Stakeholders

As is increasingly the case in most water resources problems, the decision-makers for the North Branch are numerous. The primary decision-makers are made up of the reservoir owners: the Baltimore District of the Corps of Engineers, the Upper Potomac River Commission and the three major D.C. area water suppliers. For the Corps, water control engineers who manage the reservoirs are heavily involved and will be the first line decision-makers for any recommendations that come out of the study. It is possible that the District Commander will have to approve any changes to reservoir management so ICPRB will work with the Corps to keep the Commander informed as the study evolves.

The Upper Potomac River Commission (UPRC) owns Savage Reservoir and the wastewater treatment plant in Westernport. They agree to operate the reservoir on recommendations from the Corps, but they are not required to do so. The superintendent of UPRC has been part of the North Branch Advisory Group and is participating in the Shared Vision Study.

The D.C. area water suppliers own 33% of the storage in Jennings Randolph. They paid for a proportional share of the construction cost of the reservoir and continue to pay a share of the operations and maintenance costs. In addition, the water suppliers pay for a substantial portion of operations and maintenance for Savage Reservoir, a legacy of the negotiations and agreements that allowed for the construction of Jennings Randolph. The water suppliers are open to the possibility of using water supply storage for other purposes, provided that the resulting management plan results in a benefit (or at the very least, no dis-benefit) to water supply reliability. A representative from one of the utilities has been attending North Branch Advisory Group meetings over the last two years, and attended the initial SVP workshop. Other utility representatives will be invited to participate as well.

The UPRC owns Savage Reservoir and the D.C. area water suppliers own part of the storage in Jennings Randolph Reservoir. Therefore, both will be decision-makers in this SVP process, but they are also significant stakeholders. Reservoir management can have an impact on the UPRC's ability to meet required water quality conditions. In addition, reservoir management, even with just the water quality portion of storage in Jennings Randolph, will affect low flows near Washington and, therefore, the reliability of the water supply. Both UPRC and the water suppliers will probably function more as stakeholders, but the fact that they have dual roles is important for study management. The decision-maker role gives each entity more influence as stakeholders.

The remaining stakeholders fall into one of several categories. As noted earlier, one of the primary concerns for the North Branch is water quality, and especially water quality impacts on fisheries. Therefore, one stakeholder group will address the link between reservoir management and water quality, and then the link between water quality and fisheries. The overall objective of these stakeholders is to promote a larger and healthier trout fishery in the North Branch Potomac and Savage Rivers.

Another group has been formed to address the impacts of reservoir management on recreation downstream of the reservoirs. This group will focus on whitewater boating, wade fishing, and float fishing, including commercial guide operations for each. This group will try to develop a quantitative link between reservoir releases, recreational usage and the associated economic impact to the region. ICPRB will work directly with the project manager for Jennings Randolph to study recreational activities on the reservoir itself.

All of these decision-makers and stakeholders were involved with the original North Branch Advisory Group. Those that have not volunteered for a specific task group will continue to be involved with the Shared Vision study. In addition, ICPRB is attempting to broaden the scope and address all impacted interest areas, so other stakeholders may be brought in as the study evolves.

Modeling

A major thrust of a SVP is the development of a transparent decision-support model. Usually the model is built from scratch so that it can be customized. This will not be the case for the North Branch Shared Vision Study, at least not in the early part of the study. ICPRB has a detailed simulation model of the Potomac and its reservoirs that has evolved over many years and that has previously been vetted by the Corps' water control engineers. The Potomac Reservoir and River Simulation Model (PRRISM) is used to evaluate long term water supply reliability for the Washington, D.C. region. PRRISM will be modified to support North Branch SVP.

Often legacy models are not sufficiently transparent and not sufficiently trusted for a Shared Vision context. However, partly because of ICPRB's reputation as a producer of accurate and unbiased science and partly because of efforts ICPRB is making to open up the model, there has been no resistance to use of PRRISM for this study. If the need for a new model arises, for whatever reason, ICPRB will explore the possibility of customizing a new tool for this process. In the meantime, it is important to spend some time making PRRISM understandable and trustable to the stakeholders. This will involve making detailed presentations to the group, individual meetings to explore the model, and a new round of detailed model validation with the Corps. At this time, it appears that if the Corps endorses the model, it will be accepted by the stakeholders as an accurate representation of the North Branch reservoir system.

PRRISM covers the hydrologic aspects of the North Branch—i.e., reservoir releases, tributary flows, resulting Potomac flows, and reservoir storage. Stakeholders are concerned about the impact that hydrology has on other factors, such as water temperatures and economic development associated with recreation. Consequently, new models will be developed to investigate the link between reservoir management and these other issues.

These new models will be developed in a way more typical of SVP. Early model development will be led by the fishery and recreation subgroups mentioned earlier. Available data, initial analysis, and plans for modeling will be presented to the broader group for discussion. At this point, it is unclear what kind of work will need to be done and, therefore, it is still to be determined exactly how the process will be organized. In addition to the impact-specific models, a visualization tool is being developed to help study participants interact with all the model outputs, such as calculated reservoir levels, flows and performance metrics. The goal, which has been endorsed by the stakeholders, is to have new models that can be linked with PRRISM to create a dynamic set of models that can simulate reservoir operations, resulting hydrologic conditions (flow, reservoir levels) and the likely impacts to water quality, fisheries, recreation and any other issues that are identified.

This whole package of models has been presented to the decision-makers and stakeholders as a tool for designing new management plans, evaluating their impact on important issues, and comparing tradeoffs. ICPRB has emphasized that the tools will serve as the focal point for debates and decision-making, and, so far, the stakeholders are supportive of this. Stakeholders are interested in learning more about how the system works and using the tools to find completely new ways of addressing the broad array of management objectives. In fact, PRRISM and a preliminary version of the data visualization tool have begun to support this process with considerable interest from the stakeholders and decision-makers. Many of the stakeholders will not make use of the models themselves, but they are engaging with the process of model development and supportive of using it for plan design and decision-making. The early phase of the shared vision effort has cooled tempers and resulted in constructive discussions about objectives and impacts. There is considerable work to be done, but this change in tone sets a good foundation for success.

Future Plans

The first months of this project have been focused on individual stakeholder meetings and an initial modeling workshop. The purpose of the meetings was for ICPRB to develop working relationships with each of the stakeholders and learn more about the issues important to them. The meetings are essentially part of the team-building component of SVP. The initial workshop included two main objectives: 1) a detailed presentation on how the Corps manages the reservoirs now and 2) an introduction to PRRISM, the data visualization tool and how ICPRB intends for them to be used. The modeling subgroups were also formed at this workshop.

The next several months will be focused on preliminary data gathering and analysis, along with developing initial plans for new models. ICPRB is working with the Corps and stakeholders to determine what data are available and how they could be used for modeling.

Before the study moves much further along on the modeling issue, it will be necessary to revisit the issue of stakeholder objectives. The North Branch Advisory Group spent significant time discussing management objectives, but the results are fairly general. The models and new alternative management plans will have to reflect stakeholder objectives. This can only be accomplished with a detailed set of objectives and an associated set of performance metrics.

References

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A Federal Research Initiative on CADRe?

Background: In late 2006 a working group from multiple federal agencies developed an interagency federal research initiative on the integration of computer based modeling tools within multi-stakeholder public decision processes for US water solutions (see below). These same agencies helped populate and conceptualize this workshop. This proposed initiative was a product of the National Science and Technology Council's Subcommittee on Water Availability and Quality (SWAQ). In September 2007, the SWAQ released "A Strategy for Federal Science and Technology to Support Fresh Water Availability and Quality in the United States" (www.ostp.gov/nstc/html/_reports.html).

Collaborative Tools and Processes for US Water Solutions

Hal Cardwell, USACE (SWAQ member); William Elliot, USDA-FS; Nina Burkardt, USGS; Mike Eng, USIECR; Jim Dobrowolski, USDA-CREES (SWAQ member); Vince Tidwell, Sandia National Labs

Summary

The about-to-be released SWAQ (National Science and Technology Councils Subcommittee on Water Availability and Quality), *A Strategy for Federal Science and Technology to Support Fresh Water Availability and Quality in the United States,* surveys the challenges facing the United States today and recommends federal research towards developing collaborative tools and processes for solutions to US water problems. Upon further consultation with experts from this area across the federal water establishment, this proposal refines that recommendation by proposing that the SWAQ promote a coordinated federal initiative to ***develop and advance the integration of computer based modeling tools within multi-stakeholder public decision processes for US water solutions***. Components of the proposed initiative include: A review of current uses and programs focused on the use of "collaborative decision support tools"; development of a framework for evaluation of the effectiveness of combinations of various computer tools and collaborative interventions across of range of water problems and settings; and targeted "pilot" or "demonstration" projects, or even "experiments," that can be explicitly designed to be studied and evaluated with the intent of developing recommended approaches and methodologies. The initiative will directly and concretely address the *government-wide emphasis on increased use of collaborative processes*, and both *assist state and local governments* and *support existing federal water management* roles. Federal agencies are well-positioned to conduct and coordinate inter-disciplinary research, and this initiative will provide the efficiency of a central focus for research and knowledge and provide unified direction and consistency over time. Results of the initiative will include focused interagency research on the needs for collaborative problem solving of water problems, coordinated development and dissemination of principles and best practices for effective combination of modeling and multi-stakeholder

public processes, and, ultimately, reduced level of water conflict through more broadly-acceptable, timely and sustainable solutions.

What is the Problem? What's the Objective?

Persistent conflict among competing interests and needs is increasingly common in water resources management. Too frequently, conflicts bubble outside of the control of water managers, as individuals illegally open irrigation gates, groups organize mass demonstrations to reject privatization of water services, and states sue each other over water withdrawals.   At best major water resources decision-making results in gridlock, or a protracted, inefficient, litigious decision-process that takes too long, costs too much, and leaves us without broad consensus on the decisions. These conflicts occur because of both the complexity and uncertainty in the natural systems and the conflicting interests and values across individuals, and groups. We know water managers need technical information to identify and evaluate solutions to water problems, but federal, state and local water managers also need to engage a broad range of stakeholders for those same tasks – eliciting a broad range of values and local knowledge to collaboratively identify and judge potential solutions. They need to better understand how to develop trust in both the analysis and in the process for decision making. To do that will require an understanding of process skills like facilitation, negotiation and alternative dispute resolution. And it will require a better understanding of how to integrate the technical analysis of water problems into decision making processes for *public* resources that involve multiple stakeholders.   How can water managers work with stakeholders and technical information to jointly structure the problem definition and identify realistic solutions? Modelers will need to modify existing technical tools, and practitioners will need to modify how these tools are used to interact with stakeholders. Water managers need to understand how to best involve stakeholder groups – not just once but through a longer term process of engagement - in discussions of impacts of different management alternatives, of risks and potential consequences.
Previous efforts demonstrate the value of applying technically-informed collaborative planning and management methods. These methods involve open, collaborative decision-making processes, supported by transparent computer models. Presently, small communities of practitioners are working on such methods, often independent of each other and with limited sharing of knowledge and techniques. Occasionally, agencies have modeling capabilities that are used in aiding negotiations, but very few agencies have the capacity for near real-time development of appropriate and useful decision support tools for envisioning and evaluating options.

To help water managers at all levels integrate the technical issues within collaborative processes for US water solutions, we urge SWAQ to endorse and support a federal initiative whose objective is to ***develop and advance the integration of computer based modeling tools within multi-stakeholder public decision processes for US water solutions.*** Researchers from across the federal government will need to be engaged, across social sciences, ecology, hydrology, and other disciplines.

What Current and Recent Activities Coordinate this Effort across Multiple Agencies?

Very limited formal interagency activities exist to exchange ideas and facilitate integration of computer based modeling tools within multi-stakeholder public decision processes. In part this is because the research requires skills from an array of disciplines that do not have joint annual meetings or established fora for interaction. Although the advances in computer software and increasing requirements for public access to and openness in the technical analysis have led many individual researchers and practitioners to meld the use of computer tools with collaborative processes, in most cases researchers have not been connected to exchange information and experiences. Below is a description of some of the known examples of efforts to coordinate research across multiple agencies.

- The US Institute for Environmental Conflict Resolution is a federal focus for collaborative processes for environmental problems. A recent (2005) USIECR conference had a few presentations and one session on integrating computer modeling into the decision process. USIECR's connection to the "process" community is a valuable asset to bringing together process people and modelers to jointly craft the integration of computer based modeling tools within multi-stakeholder public decision processes.
- The Bureau of Reclamation recently (2005) sponsored a forum on institutional and collaborative approaches to water solutions. While primarily focused on BuRec, representatives from the US Geological Survey, U.S. Army Corps of Engineers, DOE labs, and universities attended the meeting. BuRec is presently working with the USGS's MIT-Science Impact Collaborative program on integrating stakeholder processes with transparent decision support tools in a southeastern Colorado basin.
- The Executive Order on Cooperative Conservation (2004) and the CEQ/OMB Joint Memo directed agency heads to increase "appropriate and effective" use of environmental conflict resolution and collaborative problem solving approaches. This effort is focused broadly on collaborative approaches and not specifically on linkages between computer tools and public multi-stakeholder processes.
- The Federal Interagency Hydrologic Modeling conference is an interagency forum that brings together modeling experts from across the federal government. Currently the conference focuses on technical presentations, but it may be an appropriate venue to sponsor a track that would emphasize the integration of multi-stakeholder processes with the modeling tools.
- In 2006, the U.S. Army Corps of Engineer's Institute for Water Resource and DOE's Sandia National Laboratory began collaborating on demonstration projects, and have proposed a interagency center on Computer-Assisted Dispute Resolution. The vision of the center is to bring together multiple federal, state and academic partners to focus on computer assisted dispute resolution techniques, through training, methodological development, and technical assistance on water problems. A June 2007 symposium on Computer Assisted Dispute Resolution for water solutions is being planned with the emphasis on practitioners from Federal and state agencies.

- Internet-based resource networks such as the Ecosystem-Based Management Tools Network, The Global Water Partnership's ToolKit, Desert Research Institute's Center for Advanced Visualization, Computation and Modeling (CAVCaM), and the Ecosystem Management Decision Support (EMDS) are increasingly available for use by the public as well as scientists and managers for integration into public multi-stakeholder processes.

We caution that many of these efforts focus on one aspect of the problem (e.g. ecosystem modeling, or primarily the collaborative processes research). The examples of interagency coordination of research that explicitly link the use of modeling within public multi-stakeholders processes are very limited. Furthermore, the interaction is frequently peer-to-peer or focused on a specific water problem (e.g. Everglades restoration) without a more comprehensive look at ongoing federal research and needs.

How Can We Enhance Coordination of Existing Efforts?

The examples summarized above demonstrate that there is ongoing development of collaborative decision-making tools, but this development is sporadic, and often agency-specific. The following measures using existing mechanisms may bring focus to activities across the federal research establishment and identify specific research needs and opportunities for evaluation of tools and techniques. Building on the activities identified above, we recommend the following actions:

- Develop a track on integrating computer modeling into the public decision processes at the next USIECR conference (2008).
- Develop a similar track within the Federal Interagency Hydrologic Modeling conference.
- Identify ways within the Cooperative Conservation Initiative to promote linkages between computer tools and public multi-stakeholder processes.
- Use the upcoming June 2007 symposium on Computer Assisted Dispute Resolution to focus on research needs and opportunities for demonstration programs.
- Develop agreements (MOUs) to support a federal interagency center for Computer-Assisted Dispute Resolution. Use the center to coordinate research and demonstration projects, and provide linkages to tool boxes and references.

What Might Be Major Initiative Components?

To move beyond the important stage of sharing experiences and advances, a combined federal initiative will bring focus to specific research questions and identify needs, capabilities and opportunities (for pilot studies, etc) across federal agencies. The components of such an initiative would include:

1. A *review of current uses and programs* focused on the use of "collaborative decision support tools" in water problems with a focus on the integration of computer-based tools with collaborative process design. Highlight successful illustrative case examples.

2. Development of a *framework for evaluation of the effectiveness* of combinations of various computer tools and collaborative interventions across of range of water problems and settings. Scholars have developed methods for evaluating collaborative processes, and a large body of research focuses on program evaluation. We anticipate drawing on this considerable body of work to construct an evaluation tool. The tool will provide subjective and objective feedback about the process of utilizing computer tools in collaborative problem solving endeavors, and the outcomes of those efforts.
3. Using this framework, explicitly design *targeted "pilots" or "demonstrations"* to be studied and evaluated with the intent of developing basic principles and best practices to computer assisted multi-stakeholder approaches and methodologies. The focus on these demonstrations will be on tangible high priority needs facing the nation such as TMDLs or modified operations from multi-purpose reservoir systems. Recruit teams of experts from across the federal research establishment to jointly apply their expertise to these "ripe" decision making situations. The demonstrations will be used for learning purposes to improve methodologies and process design, and highlighted to promote best practices or pitfalls.
4. Development of a focal point or center to facilitate coordinated federal research. Use the center to coordinate research and demonstration projects, provide linkages, promote methodological development, and enable innovative applications of collaborative decision support tools.

Potential research questions might include:

- What model features or attributes (e.g. ability to do "what-if scenarios" and sensitivity analysis, transparency, integration of multiple processes) facilitate a collaborative multi-stakeholder process?
- When developing models, what actions can be taken to assure relevance to decision?
- What computer technology platforms, designs and capabilities, can improve public participation in analytic-deliberative decision making within large groups?
- How can the effectiveness of different computer-assisted techniques in a reducing conflict be measured?
- How can computer models be used to establish a common understanding of policy options across stakeholders? An example would be an agency by agency vs. more collaborative modeling approach in the Everglades.

At what points in the process are different computer-assisted representations of risk (games, graphics, etc) most appropriate for communicating with different segments of the public?

What is the Justification for Increased Federal Investment?

The federal government is uniquely positioned to address the issue of providing tools for collaborative processes involving water resources. Many of the decisions to which these tools will be applied include federal interests and resources, and federal leadership is already an important part of the collaborative process. The benefits and rationale for moving forward with a plan to provide science leadership in the area of providing tools include the following:

- This initiative directly and concretely addresses the *government-wide emphasis on increased use of collaborative processes*
- By providing new understanding and tools to support collaborative solutions to water issues, this initiative will both *assist state and local governments* and *support existing federal water management* roles.
- An important function of the clearinghouse will be to bring together researchers and practitioners from a variety of disciplines. The work envisioned in this proposal will require inter-disciplinary research, and federal agencies are well positioned to conduct and coordinate such research on a national or international level.
- This initiative can provide the efficiency of a central focus by forming a clearinghouse for research and knowledge about melding model use with collaborative processes. While universities and the private sector are likely partners in this endeavor, a federal presence will provide unified direction and consistency over time. University staff and graduate students may be expected to have the expertise and interest to perform some of the work, but the short time frames of graduate students and funding realities of university professors lead to the conclusion that federal agency personnel should provide the long term research, development, and monitoring capabilities. This is a role to which federal agencies are well suited (e.g. NAWQA).

Federal agencies operate on a public service mission. The problems of water availability and quality are central to the well being of the nation as a whole, and public servants are able to apply their expertise and service ethic to these problems.

What are the Anticipated Results of the Initiative?

Results of the initiative will include focused interagency research on the needs for collaborative problem solving of water problems, coordinated development and dissemination of principles and best practices for effective combination of modeling and multi-stakeholder public processes, and, ultimately, reduced level of water conflict through more broadly-acceptable, timely and sustainable solutions

CADRe Workshop Reflections

After the workshop, all participants were offered the opportunity to share thoughts and reflections on outcomes of the workshop and ideas on how to advance and improve CADRe.

Memo: Thoughts Upon Leaving Albuquerque

Jim Creighton

I've glanced back at my scribbles from the Albuquerque workshop, and below are a few of the ideas that stand out:

POST-MODEL EDUCATION/INVOLVEMENT PROCESS

I've been pondering the situation with the Willamette Case. Sandia seems to be well along with model building, but the process still raises problems.

It seems to me that shared vision planning has two goals.[2] The first is to build a model that is accepted as credible. The second goal is to foster the joint learning that occurs through building the model together.

Arguably the Willamette model may meet the first goal. We are hoping that when some of the key stakeholders said they would trust any model that was verified by certain modelers they trusted, they really meant it. That may be true. I'm somewhat worried that if the model generates any results they don't like, they may still disown the model. I hope not.

But the joint learning goal is not being met. I don't think any of the stakeholders not directly on the modeling team have any improved understanding of the natural resource system.

It occurs to me that we haven't spent much time thinking about how the model is going to be rolled out. It also occurs to me that there may be something innovative we can do to find a way to use the model to educate and involve the public before it is used in decision making. In my own thinking, at least, the focus has been on getting credibility for the model through participation. But I think we need to be thinking just as creatively about how to use the model to accomplish the joint learning goal.

Could we, for example, create a "game" or scenario exercise in which people would use the model to compete with another team to come up with the best win/win solution to a problem, and in the process learn the dynamics embedded in the natural resource system.

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[2] Shared vision planning (SVP) is IWR's specific application of CADRe.

Or could we create a demo in which we go around to various stakeholders and help them identify how best to meet their interests/values using the model.

I guess I'm proposing a much expanded post-model development phase in which we try to pilot alternative ways of engaging stakeholders with the model, to accomplish the joint learning. The model would become an education tool, not just a decision support. This issue of educating the broader public remains even when there has been an ideal model development phase.

I don't have any off-the-shelf techniques to offer, although I can think of several potentially worthwhile directions to go. I am reminded of an occasion some years ago when I was asked to help the Forest Service train forest land use planners to think in terms of 80-100 year cycles, not the next 20 years, and to take into account changing social/political contexts that would create different demands on the Forest. We created a game in which every round was 20 years. There were certain goals that had to be met in the next 20 years, but the social/political context also changed every 20 years. So the goals for the subsequent round might reflect very different social goals. Actually we designed the game so that if planners didn't protect their ability to meet more than just the goals demanded in the immediate next 20 year cycle, they would find that by 60-80 years out they had used up their options and would be unable to meet the goals the game demanded they meet in year 60 and year 80.

In that game, we made up rules that told us how well planners met certain goals. But with a model, we could play some similar learning games, but the difference would be that we would have "real" (at least as best the model can tell us) feedback on how well certain initiatives fared over time.

That's just one of several possibilities, but its something I would enjoy working on.

VISUALIZATION

I also left the conference believing we needed to do much more with visualization to help people understand the implications of results from the model.

I thought, for example, that Dan Sheer's little animation showing how water levels above certain heights washed away shoreline protections was extremely powerful. I could imagine that little animation forestalling weeks and weeks of argument.

Would it be possible for a team to analyze the results from the model and then develop a series of animations designed to teach the key system dynamics that people can learn from the model? The public is only "sort of" comfortable with charts and graphs, and anything we can do to make the learning more graphic would be helpful.

So again I don't have any immediate answers, but I think a program targeted at making the output from the model more graphic could have immense value.

PRACTICE DECISION MAKING

I was most intrigued by some people at the conference saying they didn't just model the natural resource system, they also had actual decision makers go through several practice rounds of making a decision, and analyzed how data was used in making those decision (I think this was on the IJC decision). In other words they began to model the decision making process itself.

I think this is a potentially a very valuable direction to go. A key issue always is the link between the modeling and the decision making. Does greater confidence in the model change how decisions get made? How do decision makers use information from the model? Do the models produce the information decision makers really need?

The big challenge, of course, is to get decision makers who would see enough value in this to act as subjects. It would have to be for some fairly big decision, such as the IJC decision, to justify the time that would be spent doing repeat rounds of decision making.

PRECONDITIONS FOR SHARED VISION PLANNING

It's very clear from both the Willamette and James River cases that one of the issues for SVP is whether there's enough stakeholder interest to get the level of participation needed to build a model with stakeholders. I think in the past many of the cases involved some people in pain, who saw SVP as a way of relieving the pain. Nobody on either the Willamette or James River seems to be in enough pain to make the commitment needed to participate fully.

I think we might profitably spend some time on the preconditions for SVP. Two things came up in the workshop that intrigued me in this regard. One was the role of the convener. Who has to convene the process in order to get sufficient participation? What are the characteristics of a successful convener?

The other thing that intrigued me was Rick Palmer's comment in his session that "You've always got to have a hook" to get participation. In the case he was talking about, the hook was a chance to shape a publication that might frame the global climate change discussion in the Northwest. That "hook" was strong enough to get rather extensive participation.

The hook on the Willamette was supposed to be to provide a factual base for making decision about a thermal market. Apparently that was not sufficient. The hook on the James was supposed to be "If you don't come up with something that addresses cumulative impacts, EPA may block all 404 permits." That also didn't seem real enough to people to get their commitment.

I suspect there's more we need to know about the preconditions for SVP.

DEVELOPMENT OF ETHICAL RULES

Mark Lorie wanted to explore ethical rules for people doing SVP. I started to dismiss it. My experience is that ethics come from inside people not from outside. But then I remembered that I'd had the same reaction when the International Association for Public Participation started talking about developing "Core Values." To me the proposed values seemed very much motherhood and apple pie.

But the reality is that IAP2's core values document has been quoted over and over again and is scattered all across the Internet. It's probably done more to gain recognition for IAP2 than anything else they've done. It might do the same for SVP. So I guess I'm saying: "Ignore my reaction and pay attention to Mark."

Email follow-up Response from Jerome Delli Priscoli

I agree with Jim on the link of SVP to decision making is key. I have seen a great reticence of Senior DM for the shared model building. At first many years ago I thought this was simply old guys not wanting or above or a little afraid of computers etc. But actually I have come to see that it is more.

Perhaps it has to do with taking away prerogatives for final negotiations among decision makers - or political deal makers. That is the model could lock things in too tightly and thus reduce the space for negotiations. I think we need to understand much more about the perceptions of key decision makers involved in some of the efforts where we have or will use SVP. I am not sure they share the same enthusiasms and incentives for SVP as many in the meeting.

Reflections on CADRe workshop

Tony Eberhardt

I thought the workshop was well organized and the right people were there to share their experiences and in-sights.

Reflections:

- Key to the success of shared vision planning is building trust among stakeholders, NGOs, government agencies and all participants in water management projects. In order to build this trust, the engineer or planner must be an expert in the art of facilitation. This expertise may come naturally to some, but generally training would be required. It was suggested in the "educational aspects" fishbowl group that engineering departments allow cross training with other departments, such as communication and public relations or social science. This could be pursued. I know MIT has given some consideration to this and other university may have as well.

- Another way to provide training would be through the wiki-pedia or other web-based mechanism through which training sights could be identified or links provided to training sites. There could also be links to professional societies that could manage short courses regarding effective CADRe.
- Even the most transparent, well run SVP programs can break down in the end. The Lake Ontario-St. Lawrence River successfully used SVP as a vehicle to get stakeholder input to a number of water management plan options. SVP also allowed various interests to hear the concerns and differing opinions – providing a way to educate and assess sensitivity. The IJC created a Public Interest Advisory Group, composed of the most vocal opponents. In the end there was a general sense of mutual appreciation for varying concerns. However, a minority of those charged with recommending final options to the IJC refused to endorse any options even though their displeasure with the direction of the investigations and evaluations was not evident or disclosed during the Study, resulting in a minority report. Some thought should be given on how to avoid this type of unethical outcome. Perhaps a “pre-Study or Project Agreement” could be signed to assure that concerns are expressed before the eleventh hour or that the decision makers would agree to participate in their professional rather than personal capacity. However, even though concerns may be expressed late in the process, SVP allows ready refinement ultimately leading to a mutually agreed upon solution.
- There were ideas expressed regarding certification as a CADRe or SVP expert which would bring more prominence to the practice. A text book or Corps publication would also help in this regard. A ASCE Journal specifically associated with water resources dispute resolution would be an important way of bringing the field forward.
- The re-shaping of water management to a more stakeholder-driven procedure could help in securing a dedicated funding source. This could be a long-range goal.

Reflections on CADRe workshop

Erik Hagen

I was trained in Shared Vision Planning (SVP) at the University of Washington and am proud to be a former student of Rick Palmer’s. I am lucky to have a colleague at the Interstate Commission on the Potomac River Basin (ICPRB) who was trained at the Institute for Water Resources (Mark Lorie), and am excited to be involved in a SVP project at ICPRB. I am in the early stages of my career, having spent 10 years at the ICPRB. At some point it will be time to find new challenges, and I have often thought that a great new direction in my career would be to embrace the field of SVP (or by another name, CADRe).

However, I hesitate for several reasons. While there are examples of incredibly interesting and motivated practitioners and projects, it is a field that has little role in most local and Federal regulatory processes. With the exception of Rick’s papers on SVP and the Institute for Water Resources' SVP website, my perception is that this field is poorly defined, is not well integrated with cross disciplines, is being implemented (for the most part) at the local level or in isolated applications, and does not seem to have a high degree of visibility within Federal planning processes (from my limited perspective). To be fair, Rick and Dan have not focused on Federal implementation. And on the flip side, there also seems to be great potential for growth, and on an optimistic note the workshop renewed my interest in the field as a potential career path.

This workshop was a very welcome step towards defining and building consensus for the definition of CADRe. As Kurt Stephenson pointed out in his opening remarks, there is no professional organization of forum for regular meetings and presentation of papers for CADRe. There are very few papers published in the field. Erik Webb, Congressional Fellow from the Office of Senator Domenici, was correct in his summary at the end of the workshop. If I may paraphrase, he said that there was a lack of agreement in the definition, status and direction of CADRe. He said it is a discipline that must first define itself before it can be forwarded as a legitimate alternative for policy-makers to consider and endorse as alternatives in Federal regulatory processes.

Consider the demand for CADRe if Federal regulatory agencies encouraged (or perhaps, allowed) applicants to use CADRe process for developing alternatives. CADRe would move beyond isolated studies, beyond the halls of academia and the Institute for Water Resources into the working real world. In Jay Lund's words, it could take over the field of water resources planning. How can this happen? It can happen through outreach and coordination with offices in Congress. Why is it unlikely to happen soon? Given the current lack of agreement on the very definition of CADRe, and again I will paraphrase Erik Webb's comments, it is difficult for a legislative body to forward such an agenda if its practitioners cannot agree on even a definition of the discipline.

There are many outstanding questions and issues that the workshop raised - is CADRe a special skill set? Is it a water-based field, or can the definition be expanded to include application in other fields? What is happening in other countries? How do we convince agencies that they are not ceding authority? How to build acceptance of CADRe? How to build science expertise and CADRe modelers? The answers to these and similar questions will be difficult but not impossible to develop, and will take time and more input from those who attended the conference.

A good, but in my view not perfect, next step was suggested by Bill Werick, that a "Water Wiki" be developed. The current plan is for Bill to develop the draft of a Water Wiki site and share limited editing power with select or perhaps all members of the workshop. Left unanswered are the questions, where would this Water Wiki be hosted, and more importantly, who would read it? I disagreed with the Bill's Water Wiki approach at the workshop, arguing that existing wiki tools (Wikipedia) are superior and immediately available, thus allowing the momentum of the workshop to continue. Since my eloquence at the meeting was as proficient as my hairline robust, I was over-ruled…or maybe it was because Bill's idea is better. Anyway, at the risk of not getting invited back next year, please allow me to re-raise the issue.

A suggestion/proposal: both Wikipedia and Bill's Water Wiki are equally valid and ought to be pursued in parallel or in coordination. There is value in Bill's approach, in that it represents a more official site that is controlled by the developers of SVP and CADRe. Content on such a site will be controlled thus preserving the ability to define the field well.

What's lacking is the broader exposure and organic power of a broader site open to anyone. Can we not better harness the power and momentum of this workshop via Wikipedia? The argument against using Wikipedia was that poor quality work and links will be posted to the site. However, those who attended the workshop will have editorial power since anyone can edit the site. There are enough practitioners of SVP/CADRe who attended the workshop who could collectively ensure quality. Ultimately, we could make links from the Wikipedia entry to the more official site developed by Bill and others, thus preserving the real intellectual and academic insights developed in the field. However, Wikipedia represents a novel way to collectively define the field and build on the case studies and papers that are out there of which we are unaware. Using a public site, we might learn what is happening in other countries and discover answers to several of the other questions raised in the workshop.

Is not the Wikipedia approach more in keeping with the spirit of Shared Vision Planning? Do we not need a collectively defined vision of what we are all about, in order to convince others that we are a legitimate alternative for policy-makers to consider and endorse as alternatives in the state or Federal regulatory processes? Would it not be advantageous to pursue this quickly?

Thank you for the opportunity to share these perspectives and for the invitation to the workshop. The workshop was well conceived and implemented, and I share the opinion I heard from at least one other that this was one of the best conferences I've attended.

From Wikipedia's (perhaps overhyped) site:

Wikipedia is an encyclopedia collaboratively written by many of its readers. It is a special type of website, called a wiki, that makes collaboration easy. Many people are constantly improving Wikipedia, making thousands of changes an hour, all of which are recorded on article histories and recent changes. Inappropriate changes are usually removed quickly, and repeat offenders can be blocked from editing...

How can I help? Don't be afraid to edit — anyone can edit almost any page, and we encourage you to be bold! Find something that can be improved, whether content, grammar or formatting, and make it better…You can't break Wikipedia. Anything can be fixed or improved later. So go ahead, edit an article and help make Wikipedia the best information source on the Internet!

Proposal for integrating social science methods and data into CADRe process support software: the Social Science Support Module, and Open Process Interface concepts

Beaudry Kock

The Modeling break-out group of the CADRe workshop explored, among other issues, the possibility of developing an ‘umbrella’ software platform to:

1. Help the modeler/stakeholder couple/integrate a diverse range of hydrologic and geospatial modeling tools, via the Open Modeling Interface (OMI);
2. Help the modeler/stakeholder seek out, obtain and organize hydrologic and geospatial information relevant to running an aggregate systems model;
3. Help guide the modeler/stakeholder through the modeling and overall Shared Vision Planning process;
4. Help the modeler/stakeholder seek out, obtain and organize social and economic information.

Points 3 and 4 of this list form the focus of this brief discussion paper. The intention is to sketch out and justify a proposal for a software platform that not only meets the considerable technical challenge of integrating hydrologic and geospatial models over different levels of model complexity and scale, but also adequately treats the problematic issue of improving the sophistication with which Shared Vision Planners and stakeholders engage with social and economic data. The software is intended to help ensure that the appropriate types and volumes of social and economic data are gathered via accepted and well-respected social science methods, organized into efficient and interoperable formats, and are transparent to both modeler and stakeholder alike.

Water resources planning models are becoming increasingly complex, incorporating social and economic concepts and modeling approaches hitherto rarely seen. Obtaining socioeconomic data in the most appropriate format, in a timely fashion and at least cost is a major challenge for engineer-planners without access to and close collaboration with social science teams. Such data is essential to improved credibility and realism for these more complex models. The typical Shared Vision Planner is unlikely to be well-versed in the more sophisticated social science techniques, data types and datasets. Yet, the utility of these techniques and data may be considerably higher than the basic options open known to the typical hydrologist, computer scientist or SVP manager: improved efficiency, better focus and enhanced credibility are among the benefits of basing socioeconomic data searches on sound social science methodology and exhaustive computer-aided search tools. In the absence of a trained social scientist on the Shared Vision Planning team, a process-oriented software tool would have a valuable contribution in guiding modelers and stakeholders towards the best social science methods for the context, the most appropriate points in the process at which to apply them, and how to manage and use the data obtained.

Even the most well intentioned development team would not be able to search out, assess and incorporate the great diversity of social science methodology, data types and datasets in a single software project on a reasonable time scale. Consequently, the

Open Process Interface concept (or OPI) is proposed. Mimicking the OMI concept discussed earlier, the OPI would be a set of protocols for evaluating, formatting and integrating social science methods, data types and datasets for use in the SVP process and the overall CADRe process support software framework. With these protocols in hand, successive SVP projects can build on the existing resource of socioeconomic tools and data described, referenced or included in the software, importing new approaches and new data in a plug-and-play format. Consequently, with increasing use, the software tool becomes more ‘expert’, and the range of options - as well as ease of use for each option - should improve.

Sketch of the Social Science Support Module (SSSM)

The first core component of such a software platform is a comprehensive database of social science methods, data types and datasets most relevant to Shared Vision Planning. Each method, data type and dataset is assigned a ‘relevancy score’ across a range of metrics (see Figure 1). These scores would enable the software to select the most appropriate suite of options at any particular point in the planning process. This is a task best suited to a close collaboration between social scientists and software engineers.

The second core component of the SSSM is a logic for identifying the decision points in the SVP process where socioeconomic data is most needed, and based on other input data and previous choices by the modeling/stakeholder team, the selection of an appropriate suite of social science methods/data types/datasets (also see Figure 1). The higher level interface would also allow the SVP team to query the system for options outside the range of the pre-determined decision point logic.

The third core component of the SSSM is functionality linking the suggested social science tools, data types and/or datasets to external databases, peer-reviewed literature, practitioner guides, and to contact details of skilled practitioners. This functionality accesses the internet as well as a SVP database, which is built upon with each successive SVP process. The functionality provides for multiple levels of flexibility in the extent to which the modeler/stakeholder wishes to seek out the information themselves, or be guided to a pre-determined range of sites and contacts. Note that, since social science tools include qualitative analysis and coding software, the linking functionality of the SSSM will incorporate direct access to these tools within the same overall interface.

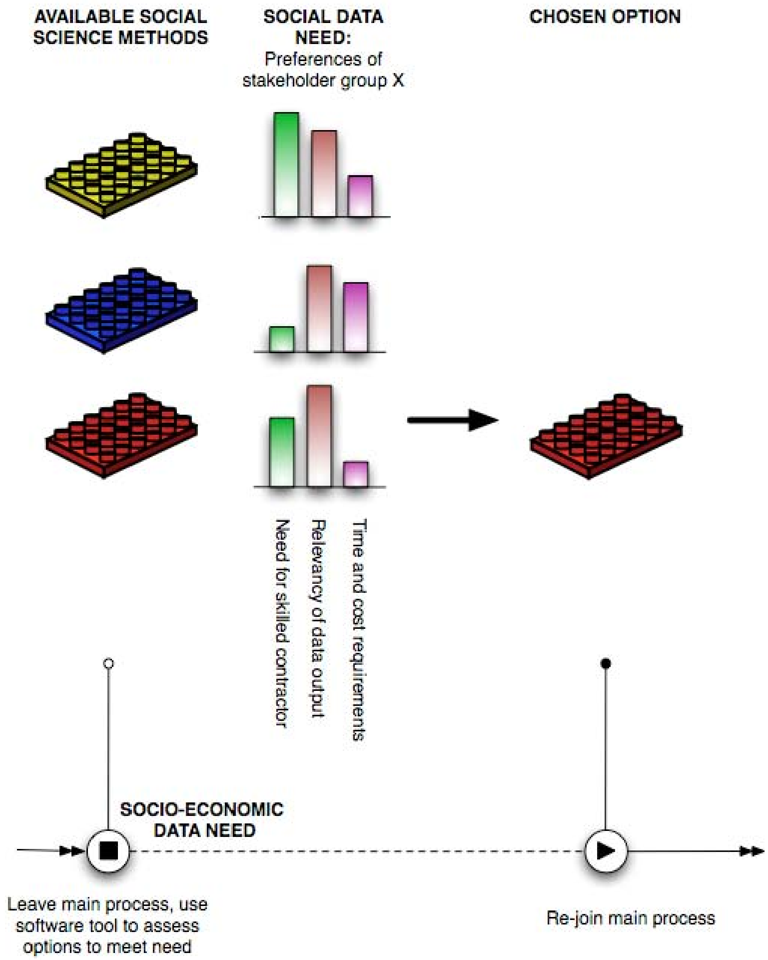
The final core component of the software is an import function that allows new social science methods (including computational tools), data types and datasets to be added to the expert system. The import function would rely on the component being pre-formatted according to the OPI protocol, to ease integration. The import function would take care of integrating the component into the existing databases, restructuring any process logic if necessary and ensuring that the updated expert system was backed up to a central SVP server for future use.

Sketch of the Open Process Interface (OPI) Protocol

In order to facilitate easy insertion of newly discovered social science tools, data types and datasets into the SSSM, a protocol is proposed that would address both qualitative and quantitative dimensions of formatting the component to be added. Qualitative dimensions would involve obtaining external expert opinion as well as stakeholder/modeler views on the relevancy of the tool in particular contexts, developing a ranking for the tool based on pre-determined metrics in the SSSM. Quantitative dimensions would vary depending on the technical nature of the component being added: a software tool would need to be wrapped appropriately to ensure a smooth interface with the SSSM; a new database would have to be linked to or imported into an SSSM-appropriate format; and a new data type would need descriptors and a place in the existing SSSM database structure.

The overall intent with the SSSM and the OPI is to build a general framework that will be enhanced steadily by increased use of the tool over time. The development challenges are significant, nonetheless, and much more detailed scoping will be necessary to assess the project's feasibility.

Figure 1: conceptual diagram to show use of ranked social science methods for meeting a SVP socioeconomic data need



Reflections on the CADRe Workshop

Jesse Roach

Based on the September 13th and 14th CADRe workshop in Albuquerque, it seems to me that CADRe is a process that has been proven in the field to be probably the best way to make water decisions when there are multiple stakeholders of various backgrounds involved. It certainly seems to have been demonstrated very effectively in the private sector, I am referring specifically to the Los Angeles water plan development described by Dan Rodrigo, as well as comments made by Dan Sheer.

However, the actual process that defines CADRe remains vague. I think we need a strawman process that defines the steps taken in a CADRe decision process, and when and where the computer aided plays a significant role, and when and why the process fails. Perhaps that exists in many people's minds, but being new to this field, I didn't sense that it defines the group.

I also have trouble with the name because I think the process we are trying to describe here can be used in the absence of a dispute, or to prevent a dispute in enlightened water planning. The CADRe acronym is nice, but for me it suggests a more limited role for the technique than might actually be realized. Computer Aided Collaborative Decision Making captures it for me despite the lack of catchy acronym.

Finally, some thoughts on the software side of things. I think that the software used to support CADRe type efforts might be lumped into the following categories:

1. Software to help stakeholders visualize technical system inputs and outputs. Can be black box as long as the interface is easy to use. Examples: HEC RPT? OASIS? WEAP?
2. Software to be used to engage stakeholders in collaborative technical model building. Must be relatively simple to learn for users of all technical backgrounds, and to this point has most often been an object oriented, system dynamics type package. Examples: Stella, Vensim, Powersim.
3. Software used in more complex models behind the scenes. Examples: Riverware, MODFLOW, HEC-RAS, HEC-HMS, MMS?, etc.
4. Software used to help stakeholders value their preferences in order to rank output from technical models. Examples: Criterium Decision Plus, other?
5. Other?

At Sandia, our bias to this point has been with the system dynamics level models as the front end that the user interacts and helps build, with all other models playing a supporting role, however a "software wrapper" project is under way to try to wrap a data set with all the different models that might access that data to provide output from the same set of inputs.

Reflections from a CADRe Cadet

Jessica Thompson

I arrived in Albuquerque not sure what to expect from the CADRe workshop. I knew I was only invited because I happened to know someone, who knew someone, and they knew that I was interested in participatory modeling and knew that I had done a few projects myself. I ran into Stacy Langsdale in a hallway of the hotel, she mentioned that she had been working on the room set-up and it had a remarkably similar furniture arrangement to her doctoral defense. We commiserated about our recent accomplishments, reminding me that if I could handle an interdisciplinary committee, I could handle anything – including the mysterious CADRe workshop. Soon I realized that I, Stacy, and many other young “cadets” (for lack of a better word) were coming from different yet similar backgrounds. I earned my PhD in a department of Communication; my committee included an expert in environmental conflict, organizational theory, communication pedagogy, a hydrologist, and a physicist. I also completed and earned two certificates on my degree: Adaptive Management of Environmental Systems and Conflict Resolution. Like many of the cadets, I came from an interdisciplinary, self-developed program and built a systems model of human behavior, using some collaborative processes to guide my model creation. This class of cadets seems to have training in both the process and the modeling aspects of CADRe, but my expertise leans more toward the process side, while others lean more toward the modeling side. How wonderful that we all found each other. Born to different disciplinary mothers, we convened in Albuquerque uniting with many of this field’s more experienced scholars and practitioners. Listening to the expert modelers, experienced sages, and wise pioneers of our field, I felt an energy and enthusiasm to be part of this community. I found myself saying: “Yes! Yes! That is exactly the kind of research I want to do!” “Yes! Yes! This is exactly where I see my career going!” “Yes! Yes! I want to engage in community-focused, action-based research to improve our management of natural resources!" “Yes! Yes! I too want to save the world!”

Despite my lack of experience and tenure among this crowd, I feel that I should share my initial thoughts on what I believe this field is. While a tad naïve and presumptuous, I have some ideas on I think this field should evolve. These brief thoughts are merely a reflection on the interactions and discussions I observed during a glorious day and half in Albuquerque.

First, it is obvious that this group included experienced water modelers. What fabulous case studies! I was impressed at the extensive, extravagant and complicated water problems being addressed. My first thought was: this must be extended to other natural resources. Why stop at water? There are many other similar scholars and practitioners working on natural resource problems across the world, some are using similar computer-aided strategies. Because of semantics and the desire to “create something new” it seems that many of these strategies have their own name, including: participatory model building, group-based modeling, mediated modeling, shared vision planning, group modeling-building, participatory integrated assessment, collaborative modeling, community-based participatory modeling. Practitioners and scholars engaging in this type of work come from numerous disciplines, including: engineering, hydrology, communication, system dynamics, sociology, environmental science, conservation biology, wildlife ecology, natural resources management, urban planning, policy and community studies, and even public health and medicine. We should not exclude these experts from our community. If we include them now, and share our methods, experiences and insights with them now, then we are paving the way for a new era in natural resource management. I want to be part of this new era.

Second, there seemed to be some debacle about a "name" and giving ourselves an identity. I think that this issue is not going to be resolved immediately because it depends on the scope of our community. If we invite all natural resources modelers, planners, and managers, then we should include natural resources in our title. However, if we stay limited to water disputes then that should clearly be a part of our identity. Of course, my preference is for a wider, natural resource community and thus a wider, more encompassing label for what we do. Likewise, we should not just come up with something for the mere joy of "coming up with something." It seems to me that we are already dealing with an overwhelming list of names describing a similar process. I would suggest selecting the most recognized, pervasive, and general label from the list: "participatory model building." Then link it to natural resources or water issues. This should help us to create an inclusive community and keep our work focused.

Also, tied to this issue of a name is the terminology of "conflict resolution." As many participants suggested, we are not entirely resolving problems, but anticipating and visioning, planning and managing problems. Many scholars in the environmental conflict arena dumped the term "resolution" many years ago – we would be ignorant to adopt the term now. Resolution implies closure, completion, and even consensus, and as we, all know conflicts are necessary and continually evolving. While achieving closure or consensus are mighty goals, they should not be the focus of our work. Our focus should be on stakeholder empowerment, shared learning, multiparty involvement and above all, collaborative processes. Resolution is an end, and if we focus on the end, we may miss some of the means, or the process, which is full of rich learning and collaborative moments.

Fourth, I believe we need to continue to include the interdisciplinary aspects of this work. While I tout myself to be a cadet, with an interdisciplinary education, including modeling and facilitation experience – this should not be the goal. We should strive to continue producing disciplinary experts with teamwork skills. At conferences, we can engage in cross-disciplinary exchanges, and discuss appropriate techniques to integrate process and modeling tools. Modelers can learn some process and process people should learn some modeling, but individuals should retain some expertise, so that we do not lose any of the disciplinary strength that brought us together. The key to our success as a field will be to retain deep expertise and learning how to work as cohesive interdisciplinary teams. Every process person should have a modeling buddy and vice versa. We should create a practitioner network, where modeling and process experts work in a team for every participatory modeling series. Just as process people recognize that they cannot create the exquisite models that modelers are trained to produce; modelers should recognize that they need the experience and training of a process person to facilitate successful stakeholder engagement. A similar sort of network should be created to link university faculty and students with federal agency and consulting practitioners.

Finally, for this field to blossom we need to start outlining parameters for success. How does a modeler or facilitator know that a workshop series was successful? What are the criteria? Is it the simple fact that the participants made a policy decision based on model outputs? So, if they do not make a decision to inform policy, is the process a failure? What about shared learning and community building – are they sufficient metrics? If so, how might we measure them? This is the most important issue I see facing our evolving field. If we are going to promote such processes then we need to have a clear understanding of their value and how to measure that value. Perhaps it will be a situational or context-based scale. Sometimes just getting polarized parties to enter the same room at the same time is a success. Maybe the fact that we did not worsen the situation is enough to deem success (I don't believe this is sufficient), but in any case, we need to actively discuss this and determine some useable parameters. This could begin with a review of the nearly 200 case studies in our fragmented field. What did the authors suggest indicated success their case? What similarities or differences among authors? This process would also be a step toward creating a theory of collaborative model building and move us beyond our case study addiction.

Ultimately, the CADRe field (or whatever we decide to call it) is a frontier field. We will never have as much strength or energy as we do right now in this exciting and evolving phase of our development. Thus, the decisions we make – what to call ourselves – who to include – what determines success – are extremely important and should be addressed with reflective and forward thought. This cadet is ready for the challenge!

Biographical Information on CADRe Workshop Participants

Name: Steve Ashby
Title: Research Hydrologist
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Bio: Mr. Ashby has spent thirty 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. Ashby received his BS from University of Southern Mississippi, a MS from Clemson, and Ph.D. from Louisiana State University.

Name: Allyson Beall
Title: Ph.D. Candidate
Affiliation: Washington State University
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Bio: Allyson Beall will complete her Ph.D. in Environmental and Natural Resource Science at Washington State University in fall of 2007. Her expertise includes the use of system dynamics as an environmental problem solving methodology. Her dissertation, *System Dynamics and Participatory Environmental Modeling: Integrating Natural Resource Science and Social Concerns*, supports the use of collaboratively built simulation models to improve environmental decision making processes. In addition, she is interested in using these models for improving the accessibility of scientific information to the public who may be affected by policy decisions based on that information.

She returned to graduate school after two decades as a land and business owner specializing in competitive performance coaching and event management in the performance horse industry. The insights from this experience were of great value when she engaged farmers and ranchers in a participatory modeling process concerning endangered species conservation and land management.

She has worked in environmental science education as both an instructor and teaching assistant. In 2008 she will be an instructor at the WSU School of Earth and Environmental Sciences. Her courses include environmental science and a NEPA environmental assessment class which she will teach from the systems perspective.

She has a MS in Environmental Science and a BS in General Biology from WSU.

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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Bio: Nina Burkardt is a Research Social Scientist with the U.S. Geological Survey in Fort Collins, CO. Her first exposure to computer-aided dispute resolution was with the Instream Flow Incremental Methodology (IFIM) and the Legal-Institutional Analysis Model (LIAM), both of which were developed by U.S. Fish and Wildlife Service researchers to help clarify instream flow allocation decisions. Since then, she has conducted research in the fields of conflict resolution and institutional analysis in a variety of policy areas, but retains a strong interest in water resources decision making. She and her colleagues continue to apply the IFIM and the LIAM, but are interested in refining the LIAM and learning about other approaches.

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: 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
Title: General Manager
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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: 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: 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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Bio: Erik Hagen is the Director of Operations for the Section for Cooperative Water Supply Operations (CO-OP) at the Interstate Commission on the Potomac River Basin (ICPRB). During dry summers, CO-OP coordinates water operations of the three major water suppliers in the Washington metropolitan area, and manages releases from Potomac reservoirs to maintain adequate Potomac flow. CO-OP assesses the reliability of the Washington area water supply every five years through demand and resource assessment studies, and conducts drought exercises every year in which the Washington water suppliers conduct "dry-runs" of drought operations. CO-OP is conducting a Shared Vision Planning study in the Potomac Basin. The goal of the study is simple: to find ways to operate Savage and Jennings Randolph reservoirs that maximizes the many uses of the river.

Mr. Hagen has a Bachelor's Degree in Civil Engineering and a Master's Degree in Water Resources Planning and Management from the University of Washington in Seattle. He worked at the Water Management Section of the City of Seattle, and now resides in the other Washington, where he has continued in the field of water resources planning and management at the ICPRB.

Name: Jordan Henk
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Bio: Jordan is Director of the Redlands Institute at the University of Redlands. The Redlands Institute conducts collaborative, interdisciplinary, applied research with an emphasis on advanced Geographic Information Science (GIS). Research applications focus on the integration of emerging geospatial science theory with information technology methods and tools. Jordan acts as Principal Investigator for two University of

Redlands' Army Research Office (ARO) grants: "GIS Program Initiative to Enhance Knowledge, Skills and Technology for DOD Research Facilities", and "Applications of GIS, Advanced Sensors and Habitat Modeling in Support of Desert Tortoise Line Distance Sampling and Translocation Studies Related to the Proposed Expansion of the Ft. Irwin NTC". Jordan is the University's Research Supervisor for several major projects with the National GeoSpatial-Intelligence Agency, the NASA Jet Propulsion Laboratory, the U.S. Environmental Protection Agency, the CA Water Resources Control Board, and others. Henk has a B.A. in anthropology and a M.S. in geography from Pennsylvania State University.

Name: Carly Jerla
Title: Hydraulic Engineer
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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: Supervising Water Resources Engineer
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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: 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 Districts, 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
Title: Director, Office of Administrative Litigation Director, Dispute Resolution Service
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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
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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
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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: Bob Pietrowsky
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Bio: Robert (Bob) Pietrowsky has served as Director of the U.S. Army Corps of Engineers' Institute for Water Resources since January 2000. As director, he provides executive and technical oversight of a diverse portfolio of water resources programs and wide-ranging national studies that support the strategic planning, policy development, and applied research needs for the Corps water resources development mission. IWR's broad program includes work on trans-boundary and international water resources issues, including administration of the U.S. Section of the International Navigation Association, technical support to the International Joint Commission, and management of USACE Memorandums of Understanding with Netherlands Rijkswaterstaat, UNESCO-IHE Delft, Japan's Ministry of Land Infrastructure & Transport, and partnerships with water centers hosted by other nations. Previously, Bob served as Director of the Federal Infrastructure Strategy Program, which pioneered the use of collaborative approaches across Federal, state and local governments, national organizations, professional associations and other NGO's.

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: Marissa D. Reno
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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
Title: Principal Member of Technical Staff
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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: Megan Wiley Rivera
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Bio: Dr. Megan Wiley Rivera joined HydroLogics in 2005, a firm which specializes in Computer Aided Negotiations and other support for water resources planning and management. Her work includes 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 to contribute and test ideas using a model of the basin.

Prior to working at HydroLogics, Dr. Rivera was on the Civil Engineering faculty at The City College of New York. Her research focused on environmental fluid mechanics with a variety of water quality and biological applications. She developed and taught courses in Water Quality Modeling, Water Resources, and Fluid Mechanics based on innovative pedagogy. She received her Ph.D. in 2001 from Stanford University in Civil and Environmental Engineering.

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: 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: Gerald Sehlke
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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
Title: President
Affiliation: HydroLogics
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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 Voinov
Title: Associate Research Professor
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Bio: Since my PhD thesis on simulation modeling of lakes, I was working on models of ponds, populations, lakes, landscapes, watersheds, and other ecosystems. Later came an interest in policies, decision making and management alternatives in attempt to actually make something change in how we handle our environment. I worked at the Computer Center of USSR Academy of Sciences and then launched one of the first independent ecological consulting companies in Russia. Since 1994 I am a research professor at the Institute for Ecological Economics at University of Maryland, and then, after 2002 - the University of Vermont, where I was also with the Computer Science Department at the School of Engineering. In 2006-07 I was an AAAS Fellow with the Institute for Water Resources, US Army Corp of Engineers. In 2007 I started my job as the Community Modeling Program Manager with Chesapeake Research Consortium. My teaching philosophy is learning by doing, and teaching skills rather than information. I am interested in promoting systems thinking and developing software tools that can help understand the complexities of this world and influence the decision making process. I am researching the new opportunities that are brought by the fast advance of web technologies that create truly distributed and democratic mechanisms for 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.

Shared Vision Planning

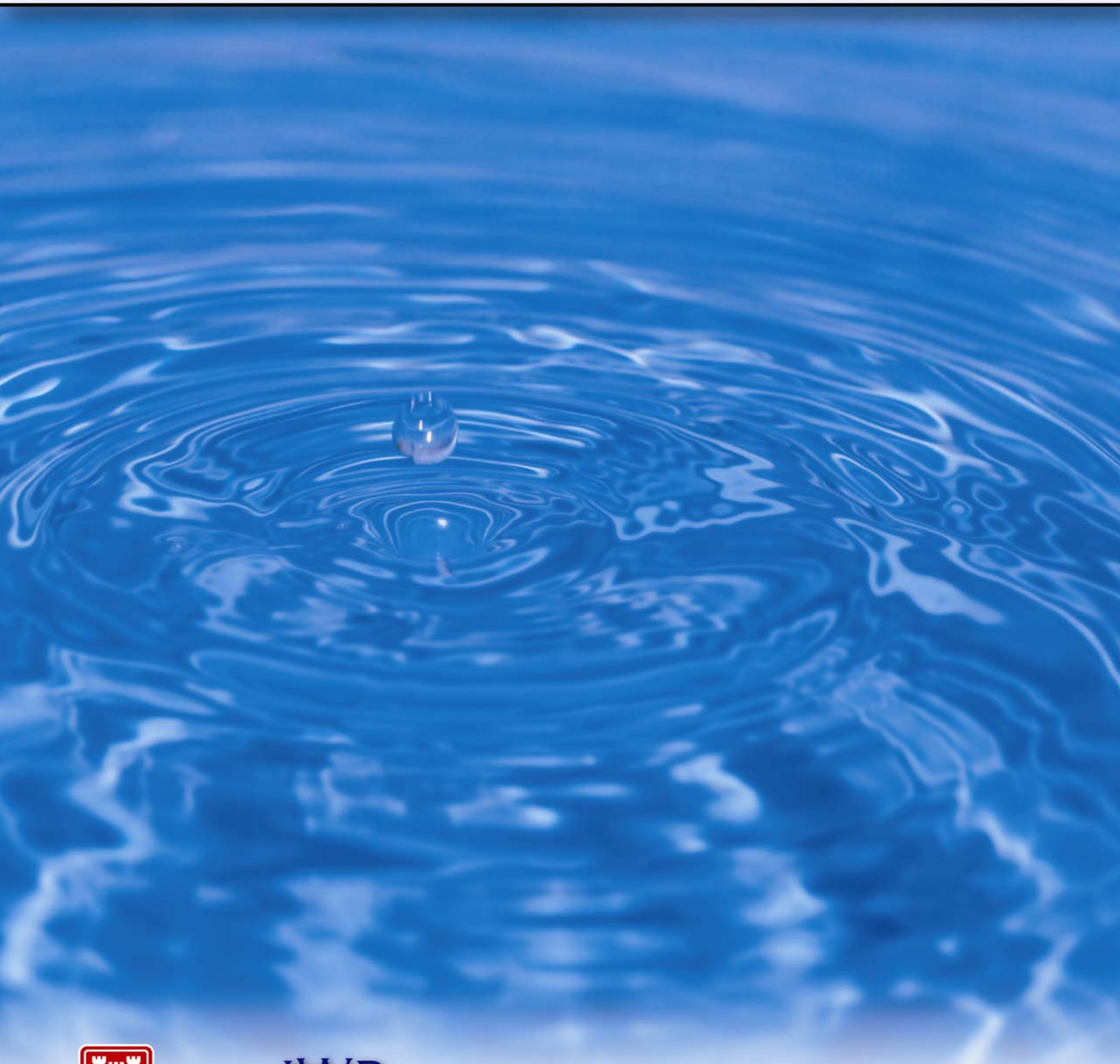
The History of Shared Vision Planning

The Shared Vision Planning approach began in response to the U.S. Army Corps of Engineers need to revise water management strategies on the Potomac River in the late 1970s. The Interstate Commission on the Potomac River Basin made public participation a key feature of its planning process to more effectively manage water supplies in the D.C. metro area.

In 1988, in response to severe droughts across the United States, the Corps undertook the National Study of Water Management During Drought (known as the National Drought Study) to examine and improve water management practices nationwide. The method developed in this project's case studies evolved into the planning approach now known as Shared Vision Planning. The "Drought Preparedness Method," as it was named during the National Drought Study, emphasized preparedness, stakeholder involvement, and the use of collaboratively developed computer models, which remain the core aspects of Shared Vision Planning today.

Shared Vision Planning and its particular method have been applied to a number of case studies since the National Drought Study, thereby refining the process and increasing Corps scientists' familiarity with it. The Lake Ontario-St. Lawrence River Study, the James River Basin Study, and the Rappahannock River Basin Commission Water Supply Planning Project are just a few of the projects that have benefited from the Corps use of Shared Vision Planning.

To further explain the concept and method of Shared Vision Planning, and educate the wider resources planning community, IWR has created a new Shared Vision Planning web site. We invite you to visit the site at http://www.svp.iwr.usace.army.mil to learn more about this collaborative planning approach.



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