APPLYING THE CONNECTIVITY APPROACH

Water and Food Supply Projects in California that Connect, Link, and Engage

Ag Innovations Network

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ABOUT CRWFS

The California Roundtable on Water and Food Supply (CRWFS) is a consensus-based forum to uncover obstacles, identify solutions, and take action to enhance water security for agriculture, the public, and the environment. Participants share a dedication to a healthy and balanced future for California, and each brings to the table deep experience on issues at the intersection of water supply and agriculture. The Roundtable membership represents a broad and balanced cross-section of stakeholders, including, but not limited to, representatives from agriculture, water supply management, government, fish and wildlife, natural resources, stewardship, environmental justice, rural economic development, and academia. Recognizing that polarized debates on water in California often end at an impasse, the Roundtable first came together in the summer of 2010 with the conviction that a creative and frank "off-the-record" dialogue could help draw out the wisdom and ideas needed to develop strong new pathways forward for water management in California. Roundtable members have found significant common ground even amid ongoing water debates.

This booklet is intended to accompany *From Crisis to Connectivity: Renewed Thinking About Managing California's Water and Food Supply* (2014). Previous reports produced by CRWFS include *From Storage to Retention: Expanding California's Options for Meeting Its Water Needs* (2012) and *Agricultural Water Stewardship: Recommendations to Optimize Outcomes for Specialty Crop Growers and the Public in California* (2011).

The following individuals participated in the California Roundtable on Water and Food Supply dialogue on connectivity and contributed to this report.

CRWFS MEMBERS*

Thad Bettner, Glenn-Colusa Irrigation District

Moira Burke, Agricola: flora et fauna

Juliet Christian-Smith, Union of Concerned Scientists

Brock Dolman, Occidental Arts & Ecology Center WATER Institute

Corny Gallagher, Bank of America Merrill Lynch

Tricia Geringer, Agricultural Council of California

Sarge Green, California Water Institute

Kamyar Guivetchi, California Department of Water Resources

Ann Hayden, Environmental Defense Fund

Rene Henery, Trout Unlimited

Glenda Humiston, USDA Rural Development

Luana Kiger, USDA Natural Resources Conservation Service

David Orth, Kings River Conservation District

Jovita Pajarillo, consultant

Mark Rentz, Integrated Natural Resources Management, LLC

Tom Rogers, Dan & Tom Rogers Farm

Dave Runsten, Community Alliance with Family Farmers

Steve Shaffer, Environmental Consulting for Agriculture

Fran Spivy-Weber, California State Water Resources Control Board

Stacey Sullivan, Sustainable Conservation

Casey Walsh Cady, California Department of Food and Agriculture

**Affiliations are listed for identification purposes only. The opinions and recommendations made by CRWFS do not necessarily reflect those of the organizations with which members are affiliated.*

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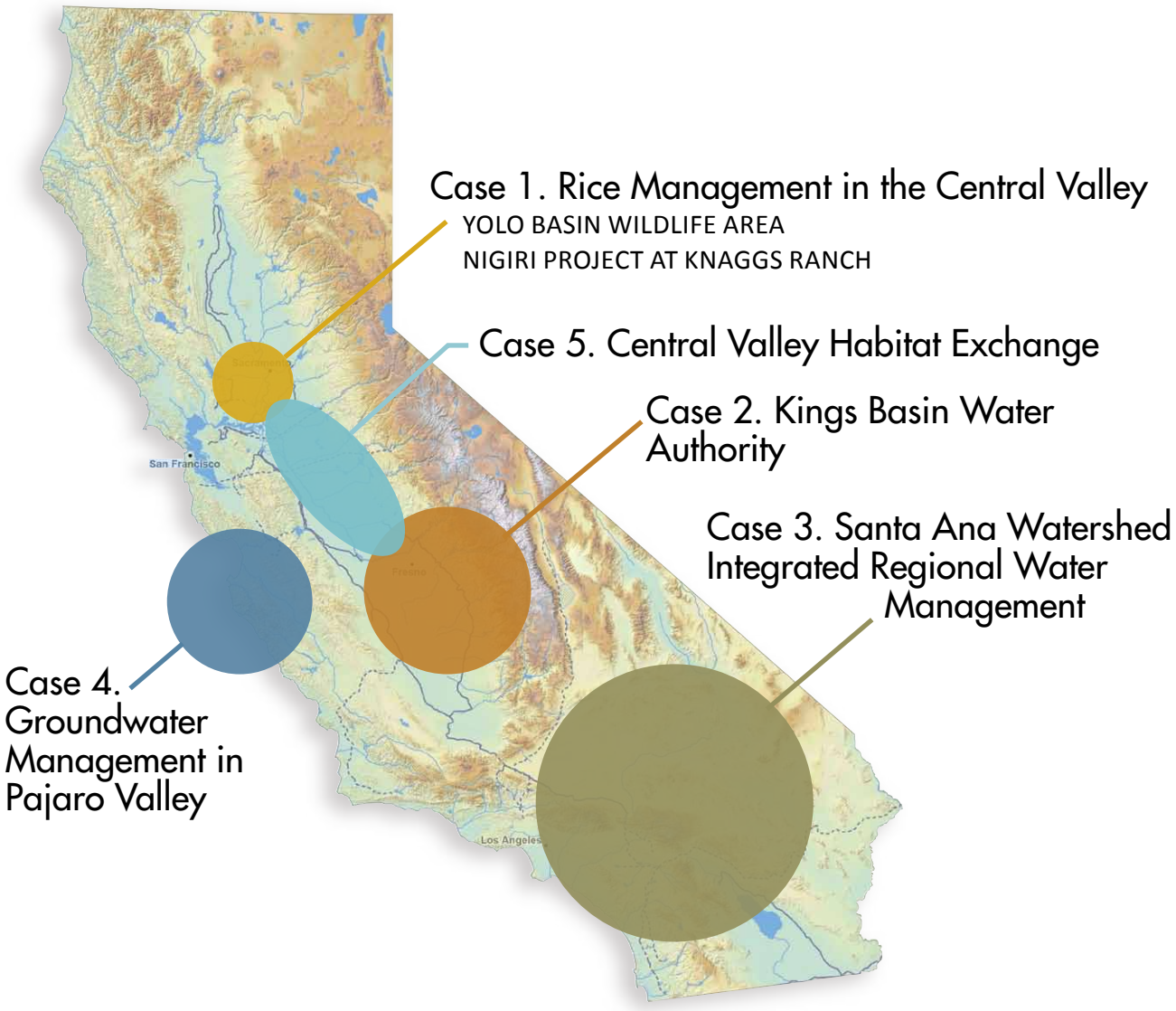
INTRODUCTION

In delving into the connectivity concept and approach, members of the California Roundtable on Water and Food Supply (CRWFS) felt that it was very important to look to existing and emerging projects that were already embracing the concepts being discussed. Projects were selected to highlight the three high-priority areas for effecting change: connected thinking, institutional linkages, and public engagement. Principles for each of these areas are described on pages 17-20.

The five examples included in this booklet as case assessments illustrate several ways the connectivity approach is currently being applied throughout California. The assessments are intended to generate ideas for applying the guiding principles of the connectivity approach and the positive impacts that emerge from them. The assessments are not meant to serve as an evaluation of the merit of the projects.

This booklet is intended to accompany *From Crisis to Connectivity: Renewed Thinking About Managing California's Water and Food Supply*,[1] which more fully describes the connectivity approach illustrated here.



CASE 1A: RICE MANAGEMENT IN THE CENTRAL VALLEY

Yolo Bypass Wildlife Area

Connectivity area: CONNECTED THINKING

Timeframe: 1997–PRESENT

Location: YOLO BYPASS (60,000 ACRE FLOODPLAIN IN YOLO & SOLANO COUNTIES)

Scale: 17,770 ACRES

Partners: WILDLIFE CONSERVATION BOARD, CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, YOLO BYPASS FISH MONITORING PROGRAM

Central Valley Background

The California Central Valley was once dominated by vast stretches of wetlands and floodplains, flanking the Sacramento River and its tributaries to the north, the San Joaquin River and its tributaries to the south, and extending hundreds of thousands of acres across the valley floor. This vast seasonal wetland mosaic was a defining characteristic of the Central Valley landscape. As a result, the historic Central Valley was perhaps the most productive wetland-floodplain complex in North America, supporting a diverse and abundant spectrum of wildlife. The heart of the Pacific Flyway, the valley provided fertile habitat for a diverse spectrum of shorebirds, waterfowl, and neo-tropical migrants. The winter and spring floodwaters that fed the vast wetlands washed young salmon and other native fishes out of the river channels and onto the floodplains where environmental conditions were optimal for growth and migration.

The once dynamic Central Valley landscape has been significantly altered over the last century — its rivers channelized and leveed, wetlands drained, and many of its habitats destroyed. Today, only five percent of the historic wetland complex still exists. From these changes, however, arose one of the most productive agricultural areas. And despite this change, the current mosaic of leveed and diverted rivers, flood-bypass channels, and agricultural lands continues to support hundreds of species of plants and animals, though at levels far below the historic abundance. However, some species, including Chinook salmon, steelhead, and several other native fishes, are teetering on the verge of collapse.

Recovery of the Central Valley's seasonal wetland and floodplain habitats requires that we apply connected thinking to re-integrate habitat and species conservation, agriculture, and flood protection into a new vision of a connected-benefit working landscape. While our understanding of connected-benefit approaches to land stewardship is still evolving, several landmark projects are already demonstrating their vast potential.

Yolo Bypass Wildlife Area

In addition to more than 1,000 miles of levees, the State Water Project includes a system of bypasses that divert excess floodwater from the Sacramento River and its tributaries to protect low-lying development and population centers. The Yolo Bypass is a 60,000-plus acre flood control channel for the Sacramento River and several of its major tributaries, which collectively carry water past Sacramento to the Delta and the ocean. Owners of the farmland within the Yolo Bypass sold easements to reclamation districts permitting the land to be flooded for a certain number of months each year when conditions warrant, while maintaining agricultural production during the remaining months. However, with continuing declines in the Pacific Flyway wintering waterfowl in the 1980s, pressure mounted to provide more Sacramento Valley habitat so that wintering ducks, geese, and swans could rest and build their energy stores before moving south or returning north to raise healthy young.

In 1997, with encouragement from conservation groups, and initiated by the state Wildlife Conservation Board, the California Department of Fish and Wildlife (CDFW)[2] acquired 3,700 acres of farmland in the Yolo Bypass and formed the Yolo Bypass Wildlife Area (YBWA). By 2014, YBWA had grown to more than 17,770 acres.[3]

While it retains its flood-control priority, YBWA's seasonal and permanent ponds have been sculpted from farmland, and they are designed to play a role in reaching the wintering population objective for the Central Valley of 4.7 million waterfowl from a low of 2.5 million in 1987. Other benefits from the restored wetlands include habitat for shorebirds, wading birds, upland game and hundreds of other wildlife species; waterfowl and upland game hunting; outdoor classrooms; birding; and fishing.

CONNECTED THINKING

1. Understand natural systems: Integrated thinking and science-based solutions

Researchers working through the CDFW, YBWA and the Yolo Bypass Fish Monitoring Program overseen by the Department of Water Resources, have contributed significantly to the body of science on the role of wetland and floodplain habitat in the ecology and conservation of native fish and waterfowl. While the Yolo Bypass continues to be managed primarily for flood control, since the creation of the YBWA, state scientists and wildlife managers have seen striking results in bird population response and juvenile fish growth. Several key fish passage and habitat improvements are still necessary however, in order for it to fully realize its potential as seasonal habitat.

2. Recognize that water, farmland, and habitat are finite resources that depend on each other

The management approach employed in the Yolo Bypass highlights the savings that are achieved when floodwater storage and habitat restoration are accomplished in a way that allows lands to remain in agricultural production. At the same time, it serves as a model for the range of beneficial functions possible for agricultural lands on historic floodplains.

6. Avoid unintended negative consequences of past and emerging approaches

Land use over the bulk of the 20th century progressively decoupled ecosystem processes from land management. The result was a fragmented, single-purpose landscape, and the near collapse of many native species. The looming reality of a changing climate, rising costs of water infrastructure maintenance, and growing water scarcity all point to the opportunity for land stewardship that reconnects agriculture, habitat, and flood management in an integrated, fiscally responsible framework. The Yolo Bypass and the YBWA serve as a canvas for, and first step towards, this new paradigm.

Benefits from the restored wetlands include habitat for hundreds of birds and other wildlife species, hunting, outdoor classrooms, birding, and fishing.

Opposite: *Pintail utilizing the rice fields of the Yolo Bypass.* Above: *Pelicans at a pond near the freeway in the Yolo Bypass.* Photos courtesy of Dave Feliz, California Department of Fish & Wildlife.

CASE 1B: RICE MANAGEMENT IN THE CENTRAL VALLEY

Nigiri Project at Knaggs Ranch

Connectivity area: CONNECTED THINKING

Timeframe: WINTER 2011/2012-PRESENT

Location: NORTH END OF THE YOLO BYPASS, 11 MILES NORTHWEST OF SACRAMENTO (YOLO & SOLANO COUNTIES)

Scale: 1,700 ACRES

Partners: CALIFORNIA DEPARTMENT OF WATER RESOURCES, CALTROUT, AND UC DAVIS

Nigiri Project at Knaggs Ranch

Managed seasonally for native fish and waterfowl habitat as well as rice production and flood control, the Nigiri Project[4] is an exciting step towards a new connected-use management paradigm for the Yolo Bypass. Innovative use of existing agricultural infrastructure allows for the seasonal creation of floodplain habitat for endangered native fishes and waterfowl during winter and spring each year on fields that remain in agricultural production in summer and fall. Centered on the 1,700-acre Knaggs Ranch at the northern end of the Yolo Bypass, approximately 11 miles northwest of Sacramento, California, the project proposes to incrementally develop a flood-neutral[5] management approach for agriculture, fish, and waterfowl over thousands of acres in the Yolo Bypass.

The Knaggs Ranch experiment in floodplain agriculture[6] has received early acclaim for its success rearing juvenile salmon on winter inundated rice fields. Growth rates for juvenile salmon in the first year of the project were among the highest recorded in freshwater Central Valley habitats.[7] Additionally, fish body condition after six weeks of rearing in the experimental fields was similar to those observed for juvenile Chinook foraging in the food-rich waters of the coastal ocean during summer.[8] These results indicate that seasonal inundation of agricultural lands can provide excellent food-rich rearing habitat for Chinook salmon.

Rice production at Knaggs Ranch has continued with little impact from the new management practices of extending the winter inundation period for waterfowl through the spring (approximately April 1) for salmon. As the project continues fine-tuning its approach, those involved are also exploring the relative benefits for fish and rice production of different soil treatments prior to inundation, including rice stubble, disked soil, or fallow herbaceous vegetation. To date, farmers are supportive of the Nigiri Project because the ecosystem-friendly uses of the bypass can provide additional funding for infrastructure. Additionally, there is a longer term-potential of assessing value to the landscape based on the habitat it provides.

While the scalability of the Knaggs Ranch approach has yet to be conclusively demonstrated, there is little indication that the approach will not be easily replicated. The success of the Nigiri project has already spawned similar pilot efforts on rice fields in the Sutter Bypass. With rice fields comprising the dominant form of agriculture on the historic lowland floodplains of the Sacramento River drainage, the potential for replicating the Knaggs approach holds great promise for fish and farmers alike. Knaggs Ranch has been selected as a pilot site for testing the Central Valley Habitat Exchange (described in Case 5) in 2015, which will further explore the opportunity for scaling up the project.

CONNECTED THINKING

1. Understand natural systems: Integrated thinking and science-based solutions

The Nigiri Project at Knaggs Ranch has advanced the science of floodplain restoration in the Central Valley. While the benefits of Central Valley wetland habitat and the YBWA for waterfowl have been well established, it is only in the last decade that researchers have begun to view floodplain restoration as a core component in the quest to recover salmon and other native fish populations. Not only has this landmark effort affirmed the highly productive nature of floodplains and the improved growth exhibited by salmon that rear on them, it is actively providing and refining a model for simultaneously providing habitat, flood protection, and agricultural production. The project is achieving connected benefits through sound science.

2. Recognize that water, farmland, and habitat are finite resources that depend on each other

In the northern portion of the Central Valley, rice production is one of the dominant land uses on historic floodplains. Rice production in the Central Valley is critical to the economy and food security of California, the US, and many nations around the world that depend on California rice exports. Both rice production and the recovery of salmon populations — also a critical food resource and backbone of the state's agricultural economy — depend on the availability of our scarce water supply. By reconnecting the benefits of rice production, salmon recovery, and water for inundation, Knaggs Ranch provides a model for responsible and integrated stewardship of these finite and precious resources.

The Knaggs Ranch experiment in floodplain agriculture has received early acclaim for its success rearing juvenile salmon on winter inundated rice fields.

Opposite: *Birds on Knaggs Ranch fields.* Above: *Juvenile Chinook salmon raised at Knaggs Ranch.* Photos courtesy of Jacob Katz.

CASE 2: KINGS BASIN

Kings Basin Water Authority

Connectivity areas: CONNECTED THINKING, INSTITUTIONAL LINKAGES

Timeframe: 2001–PRESENT

Location: KINGS GROUNDWATER BASIN (FRESNO, KINGS & TULARE COUNTIES)

Scale: 1530 SQUARE MILES

Partners: NEARLY 60 PUBLIC, PRIVATE, AND NONGOVERNMENTAL ORGANIZATIONS

Background

Historically, management of water resources in the Kings River Basin had been limited to independent operations by overlying local water agencies and individual users. This approach exacerbated the problem of groundwater overdraft and constrained the scope of potential solutions, as each water supplier only managed within its district boundaries and with its individual resources.

Although the four water agencies in the Kings Basin had worked together for decades to actively manage the region's water, they formed a Basin Advisory Panel[9] in 2001 to collaboratively manage existing water supplies and develop new supplies. Working closely with the Department of Water Resources, the water agencies initiated a specific process focused on regional cooperation. In 2004, the Basin Advisory Panel solicited wider stakeholder participation. Through these outreach efforts, the group expanded and formed the Upper Kings Basin Water Forum (Water Forum), to increase communication and collaboration in the creation of regional solutions for water resources management.

In response to the state's Integrated Regional Water Management (IRWM) program, the Water Forum grew into the Upper Kings Basin Integrated Water Management Authority in 2009, now known as the Kings Basin Water Authority (KBWA). KBWA includes nearly 60 public, private, and nongovernmental organizations.

The formation of KBWA is a significant event supporting critical collaborations that have resulted in a number of very successful regional water solutions — solutions that generate connected benefits.

Groundwater Overdraft

Groundwater overdraft is the primary issue facing the Kings Basin. Over the past 40 years, groundwater levels in the Fresno area have dropped by 40 feet. In Raisin City, a small community southwest of Fresno, groundwater levels have dropped by 150 feet. Overdraft is a result of water demand exceeding available surface and groundwater supplies as they are currently developed and managed. Such groundwater overdraft is unsustainable, particularly with urban growth pressure in the region and the need to sustain its agricultural economy.

Over the last several decades, regional irrigation districts have built groundwater recharge basins to capture floodwater. But the need is far greater. More than 10.8 million acre-feet of water has left the Kings River service area in the form of flood releases since the 1950s,10 enough water to fill the Kings Basin's primary storage facility, Pine Flat Reservoir, more than ten times. The Kings Basin region needs more water projects that can utilize flood water for urban areas, agriculture, and the environment.

The consequences of groundwater overdraft include declining water levels,

increased pumping costs, land subsidence, and migration of poor-quality water. In the long term, groundwater overdraft could also impact economic development opportunities, cause conflicts between overlying users, and result in litigation to define rights and entitlements, possibly leading to legal adjudication.

CONNECTED THINKING

1. Understand natural systems: Integrated thinking and science-based solutions

When the Kings River Conservation District, Alta Irrigation District, Consolidated Irrigation District and Fresno Irrigation District formed the Basin Advisory Panel in 2001, it was to work together to manage existing water supplies and to develop new supplies. Water district representatives began sharing surface water supply and distribution data, hydrogeology data, and groundwater contour maps to explain the movement of groundwater throughout the Basin. This information is collected, compiled, and reported through several water resources monitoring and modeling efforts that have been reconciled though the region's integrated planning effort. Examples include the development of an integrated groundwater and surface water model for the Kings Basin, administration of the Irrigated Lands Regulatory Program, coordinated groundwater level and land subsidence monitoring, and the Kings River Fisheries Management Program. Coordination of data collection and conditions reporting has helped to illustrate that the actions of one entity affect others within the Basin.

2. Recognize that water, farmland, and habitat are finite resources that depend on each other

KBWA's success is a result of an inclusive process that brought together water resource managers (representing the irrigation districts that deliver agricultural water in the basin), environmental organization members, social justice representatives, and municipal water district staff to collaborate on regional water management solutions. Together, they developed a list of twenty regional goals and measurable objectives that recognized the interconnectedness of water, land use, and environmental resource issues. Since the early 2000s, KBWA has received nearly $54 million in state and private financial support for use towards planning activities and to construct projects that address goals and objectives linked to groundwater management, water conservation and efficiency, water quality, riparian habitat, flood corridors, and disadvantaged community drinking water and wastewater concerns.

5. Focus on long-term goals versus short-term fixes

Water resources challenges in the Kings Basin are numerous and complex, and will be costly to overcome. In response to that challenge, KBWA has designed long term regional goals and objectives to be achieved over the course of a 20-year planning horizon. Because not all communities and districts chose to participate in KBWA, regular tracking of all activities that help to accomplish

The formation of the Kings Basin Water Authority is a significant event supporting critical collaborations that have resulted in a number of very successful regional water solutions that generate connected benefits.

Opposite: *Fresno Irrigation District's Jameson Pond Expansion, funded through a collaborative, consensus-based process of KBWA members.* Above: *Pine Flat Dam, representing the main water supply for the Kings Basin.* Photos courtesy of Kings Basin Water Authority.

Above: *The upper reaches of the Kings Basin water supply.* Photo courtesy of Kings Basin Water Authority. Opposite: *One Water One Watershed Pillar meeting.* Photo courtesy of Santa Ana Watershed Project Authority.

the goals of the region has proven problematic. However, early performance trends are positive, and annual reporting on the voluntary regional water conditions plans help prioritize regional needs related to projects, additional planning, data acquisition, and outreach and education. In addition, integrated regional planning can benefit from developing common sources of knowledge, which contributes to achievement of connected benefits. In the case of KBWA, an integrated planning document and a regional hydrologic model provide important information about the current state of shared groundwater resources, while allowing KBWA to consider the impacts of different water management strategies. For example, the understanding by KBWA members of the nexus between land-use decisions and the hydrology of groundwater results in better planning of urban growth and agricultural development.

INSTITUTIONAL LINKAGES

1. Move beyond institutional goals and entrenchment

Establishing trust between stakeholders with largely uncommon interests is critical to overcoming silo-based thinking that has defined much of California's water management decisions. KBWA's collaborative process has been a paradigm shift for water agencies in the Kings Basin region largely because it facilitated the development of trust among diverse stakeholders through monthly, in-person meetings. These meetings, while facilitated and focused, are casual and intended to stimulate discussions that would likely not exist outside of the format. Over time, this process has alleviated the sources of tension between groups, has strengthened understanding of neighbors' points of view, and revealed many new mutual goals and interests.

KBWA struggled with the decision to identify an appropriate regional governance structure because of the diverse needs of its many stakeholders. Not all of the participants had funding to contribute to a budget, but all of the participants wanted to be involved in the decision-making process. To protect the public agencies from risk and liability and provide the best legal structure, group formed under the California Joint Powers Act. To encourage full participation, the Joint Powers Agreement created an Advisory Committee to allow non-public organizations a place at the table. Advisory Committee meetings are held prior to each meeting of the full KBWA Board to discuss items and provide recommendations regarding virtually all actions to be considered by the Board.

Strong stakeholder participation is the foundation of KBWA's success. Several work groups have been formed by the Advisory Committee to deal with specific issues and tasks, and report back to the Committee with recommendations and updates on activities. Work groups provide an additional opportunity for stakeholder involvement and cross-institutional linking, and include: Groundwater Monitoring Work Group, Projects Work Group, Model Work Group, IRWMP Update Work Group, Disadvantaged Communities Work Group, and Outreach Work Group.

Background

The Santa Ana Watershed Integrated Regional Water Management (IRWM) Plan is known by stakeholders as the One Water One Watershed (OWOW)[11] Plan. Begun in 2007, the plan's mission is to create opportunities for collaboration to find sustainable watershed-wide solutions among diverse stakeholders from throughout the watershed. It provides a blueprint for water resources management over 30 years, identifying the need to address four major threats: climate change, Colorado River drought conditions, Sacramento-San Joaquin Delta vulnerability, and population growth and development. The process to develop the plan identified three broad areas where action is needed: the development of a water ethic that values water differently, a more collaborative approach to water management, and the construction of sustainable water infrastructure.

The OWOW initiative illustrates and embodies the three guiding principles — connected thinking, institutional linkages, and public engagement — to increase and shape connectivity in the water and food system in California. In this assessment, we are using this project to highlight how connectivity can be improved in the domain of institutional linkages and public engagement.

INSTITUTIONAL LINKAGES

1. Move beyond institutional goals and entrenchment

OWOW began in 2007 with participation from 178 officials representing more than 100 agencies in the watershed's three counties; the business, agriculture, environmental, and environmental justice communities; and the general public. Technical experts from all sectors grouped into ten disciplines, or Pillars: water supply reliability, flood risk management, water quality improvement, environment and habitat enhancement, water recycling, parks/recreation/open space, water use efficiency, climate change, water and land use, and environmental justice. The Pillars supported a Steering Committee comprising public officials from counties and cities in the watershed, representatives from the environmental, regulatory, and business communities, and representatives from the Santa Ana Watershed Project Authority (SAWPA). The Steering Committee was responsible for developing the OWOW Plan.

2. Address conflicting policies and regulations

The fundamental concept for this planning process was to pull parties together in every aspect of the water arena – those who provide water, those who manage it, and those who use it – in a way that has never been done before, and reaches beyond the interests of any one agency. This approach marked a major shift from planning efforts preceding IRWM by greatly expanding the number and type of agencies and organizations involved in the process.

CASE 3: SANTA ANA

Santa Ana Watershed Integrated Regional Water Management

Connectivity areas: INSTITUTIONAL LINKAGES, PUBLIC & STAKEHOLDER ENGAGEMENT

Timeframe: 2007–PRESENT

Location: SANTA ANA WATERSHED (SAN BERNARDINO, RIVERSIDE, ORANGE & LOS ANGELES COUNTIES)

Scale: 2,650 SQUARE MILES (4.8 MILLION PEOPLE AS OF 2000)

Partners: 178 OFFICIALS REPRESENTING MORE THAN 100 AGENCIES IN THE WATERSHED'S THREE COUNTIES; THE BUSINESS, AGRICULTURE, ENVIRONMENTAL, AND ENVIRONMENTAL JUSTICE COMMUNITIES; THE GENERAL PUBLIC

4. Shift from 'one-size-fits-all' solutions to collaborative, regionally-appropriate, whole systems strategies

The collaborative, transparent, and watershed-wide approach embraced by the OWOW planning process builds upon previous planning efforts in the watershed, such as the 2005 Santa Ana Integrated Watershed Plan. It is an attempt to change the way in which water and other environmental resources are managed in the watershed, moving from exclusive reliance on large centralized infrastructure projects to a systems approach that complements existing centralized infrastructure with decentralized facilities (e.g., groundwater desalination), technology, natural infrastructure, and human capital. One example is the Brine Line,[12] used for salinity management. An extensive collection system consisting of 5 reaches, the Brine Line collects brine or salty water from de-salters located throughout the upper watershed, and other salt-producing industries such as power generators salt-concentrating cooling towers, food processors etc. The brine is piped to the Orange County Sanitation Plan, which treats it for discharge into the ocean. The goals of the system are to prevent salty groundwater from rising into the Santa Ana River, which supplies water to cities throughout the watershed; clean up salty aquifers by removing salt so that the water can be served to customers; and reduce salt in groundwater so that recycled water can be blended to further leverage reliable water supplies for the Santa Ana River Watershed.

6. Design and implement approaches to manage the transition from existing to new practices

SAWPA served as the Regional Water Management Group (RWMG) for the OWOW planning process. While SAWPA facilitated the process and provided technical input and support through its staff and consultants, the diverse group of stakeholders on the Steering Committee, with support from the Pillars and comments from the public, developed the goals and strategies of the Plan and managed the decision-making process.

This new management style approach – inclusive, collaborative, bottom-up – will help the Santa Ana region shift toward project planning and implementation practices that look for connected benefits that improve the health of the overall watershed. With the previous structure of resource management, such inclusive, regional, connected project design would not have been possible.

PUBLIC & STAKEHOLDER ENGAGEMENT

2. Public action from the ground up

The OWOW planning process takes a "bottom up" approach to governance. Unlike in previous SAWPA plans or other planning approaches across the state, every effort has been made to allow the key discussions of major water resource issues, concerns, problems, goals and objectives, and potential solutions to originate and be first fully vetted at the stakeholder level, with participation from the greater public. By opening the doors on the ground level, the process invites greater collaboration in an effort to generate more buy-in and support for the new planning development process from the whole community.

Additionally, by expanding the number and types of parties at the table together, that manage water, deliver water, and use water, no single interest can dominate.

3. Communicate with the public

The planning process has been an open process. Communication with the public[13] was primarily conducted through the many OWOW participants, who acted as liaisons with their respective communities. Public workshops were held several times a year, but Pillar groups met as needed to develop their recommendations and to vet proposals that rose through the process. Pillars consisted of 8-25 participants, depending on the Pillar.

4. Increase awareness and effectiveness of educational programs

Water use efficiency and landscaping was one of the priorities of the OWOW Plan and the Pillars spent considerable time sharing information and pooling ideas across the watershed. This focus generated greater awareness of gardening and water use efficiency practices in schools and in after school programs. Several school garden and youth programs, including Think Together[14] and Eagle Scouts have benefited from this information sharing, and are now using it in their programs.

Background

California's Central Coast is a unique agricultural region where most farms rely primarily on groundwater. Seasonal surface water from natural rivers, streams, and creeks primarily serve to recharge the groundwater. Because of their proximity to the ocean, coastal communities face a unique challenge to their groundwater reliability: seawater intrusion into coastal freshwater aquifers.

Along the Central Coast, where many acres of valuable agricultural land lie at or below sea level, declining groundwater levels (due to overdraft) have enabled seawater to move inland into underground aquifers. At a certain point, saline groundwater supplies become unsuitable for irrigation. Coastal water suppliers, therefore, are very interested in groundwater recharge — higher groundwater levels slow the penetration of saltwater into the aquifer and sustain the aquifer's use into the future.

The Parajo Valley[15] lies within the Central Coast and has been overdrafting groundwater since the 1950s. Nevertheless, little was done until 1984, when the Pajaro Valley Water Management Agency (PVWMA) was created by state legislation to manage groundwater. For the next 25 years, the focus was on building a pipeline to the Federal/State Water Project in Hollister, about 25 miles away, in order to bring supplemental water to the valley. In 2009, the pipeline was taken out of the local plan by the PVWMA after years of opposition by farmers, who feared the cost, and by environmentalists, who feared more urban development.

The best current estimate is that the region draws an average overdraft of about 12,000 acre-feet per year. To truly halt the saltwater intrusion, however, groundwater pumping would need to decrease and/or recharge would need to increase by a combined gain of approximately 20,000 acre-feet per year. The landward movement of seawater into the aquifer averages 200 feet per year.[16] Seawater intrusion has moved further inland over the past 25 years, and even more inland seawater intrusion is expected, especially during drought events as groundwater pumping activity increases and recharge decreases.[17] Many wells near the coast have become too salty to use.

In addition to increased water demand from the Central Coast's population growth, agriculture is also demanding more of the scarce resource. Berry production has been on the rise, as the use of drip irrigation has allowed for the expansion of berry production onto hillsides, which means that many new acres of land are competing for diminishing water supplies.

In response to the overdraft challenges, berry producer Driscoll's and a group of large landowners created the Pajaro Valley Community Water Dialogues. The entire community was invited to discuss proposals for how to best move forward, and out of this process, several key solutions were developed and implemented by a wide range of stakeholders, including the PVWMA.

CASE 4: PAJARO VALLEY

Groundwater Management In The Pajaro Valley

Connectivity areas: CONNECTED THINKING, PUBLIC & STAKEHOLDER ENGAGEMENT

Timeframe: 2009 – PRESENT

Location: UPPER PAJARO WATERSHED (SANTA CRUZ & MONTEREY COUNTIES)

Scale: 144 SQUARE MILES

Partners: DRISCOLL'S, PAJARO VALLEY WATER MANAGEMENT AGENCY, RESOURCE CONSERVATION DISTRICT OF SANTA CRUZ COUNTY AND MANY LANDOWNERS, FARMERS, FARM ORGANIZATIONS, ENVIRONMENTALISTS, GOVERNMENT AGENCIES, UNIVERSITY RESEARCHERS, THE REAL ESTATE INDUSTRY.

The Pajaro Valley Community Water Dialogues is a forum to create connections among stakeholders and develop practical solutions to groundwater overdraft in a public venue.

Previous Page: *Community Water Dialogue member, Chuck Allen, holding a map of Wireless Irrigation Network towers.* Above: *Kelley Bell of Driscoll's talking to the community about irrigation and nutrient management.* Opposite: *A group of Community Water Dialogue participants touring a groundwater recharge basin.* Photos courtesy of Resource Conservation District of Santa Cruz County.

CONNECTED THINKING

1. Understand natural systems: Integrated thinking and science-based solutions

As the local people came to grips with having to live within the water budget of their local watershed, they gained a new appreciation for groundwater recharge and realized they lacked data on how and where the aquifer recharged. Professor Andrew Fisher at UC Santa Cruz built a mobile testing unit to field test absorption rates in places people thought would be good for recharge. He also built a Geographic Information Systems (GIS) model to identify areas likely favorable for recharge, so that people could see the best recharge areas on a map. Many of these areas were at the base of the mountains, and the local land trust began a campaign to preserve the upper watershed on these mountains.

3. Emphasize connected-benefit projects

The city of Watsonville needed to improve its treatment of sewage water in order to meet standards for the federal marine sanctuary in Monterey Bay. A solution was found by having the PVWMA finance a new water treatment plant and a coastal distribution system so that the treated water could be used in agriculture, near the ocean where wells had become salty. All water users in the basin benefited from this project and collaboratively funded the system. This solution solved the city's sewage treatment challenge, reduced pumping of groundwater near the ocean, contributed to reducing saltwater intrusion into the aquifer, and so also reduced the threat to wildlife of salinity in nearby estuaries.

PUBLIC & STAKEHOLDER ENGAGEMENT

2. Public action from the ground up

Driscoll's, based in Watsonville and the largest producer of berries in the world, has been leading a series of pilot efforts to optimize the use of drip irrigation. All of the berries in the region are already on drip, but the project is carefully monitoring water usage through new water-saving technologies.

After testing half a dozen approaches, Driscoll's settled on the Hortau[18] soil moisture monitoring system to measure soil moisture tension and to schedule irrigation only when it is truly needed. By requiring farmers to measure their water use with this system, Driscoll's has been able to save an average of one acre-foot of water on each acre of berries. The trials have shown no loss of yield with reduced irrigation and it appears that the quality of the berries actually improves.

The challenge is to achieve widespread adoption of the technology throughout the Pajaro Valley. A system of Hortau towers, managed by the Resource Conservation District of Santa Cruz County, was set up across the valley so that farmers could tap into the system at low cost. However, there is a cultural and language disconnect between the project implementers

and the majority of strawberry growers and irrigators, predominantly Mexican immigrants who speak little to no English. Engaging the Spanish-speaking community of growers is critical to the success of the project. To meet this need, the Resource Conservation District and the Strawberry Commission are coordinating a Spanish-language outreach program to explain the overdraft problem and the advantages of the water-saving technology. Support from the other berry shipping firms beyond Driscoll's is also being sought, since they could require their growers, through their contracts, to adopt this technology and measure water use.

3. Communicate with the public

A key lesson from the Pajaro Valley is that efforts to stop overdrafting of groundwater need to better engage both agricultural landowners and produce shippers. Both of these groups can influence growers' practices and both are financially invested in on-farm practices since the value of the land is a function of its profitability. These stakeholders must see that they will experience financial consequences if they do not engage in solving the problem of groundwater overdraft.

The Pajaro Valley Community Water Dialogues, started by Driscoll's, involved a wide array of stakeholders, including landowners, farmers, farm organizations, environmentalists, government agencies, the water agency, university researchers, and the real estate industry. It was a forum to create connections among stakeholders and develop practical solutions to groundwater overdraft in a public venue. This was so successful that PVWMA adopted the resulting solutions as its own plan.[19]

4. Increase awareness and effectiveness of educational programs

The Community Water Dialogues have increased awareness of several on-going water conservation efforts including increased irrigation efficiency, rotational fallowing, and a pilot program on performance-based conservation incentives. The Dialogues are coordinating trainings in irrigation scheduling, including use of evapotranspiration data and understanding measurements of distribution uniformity, which are critical for optimizing irrigation efficiency.

CASE 5: CENTRAL VALLEY

Central Valley Habitat Exchange

Connectivity areas: CONNECTED THINKING, INSTITUTIONAL LINKAGES

Timeframe: EMERGING

Location: CENTRAL VALLEY

Scale: 781 SQUARE MILES

Partners: AMERICAN RIVERS, AUDUBON, CALIFORNIA DEPARTMENT OF CONSERVATION, CALIFORNIA FARM BUREAU FEDERATION, CALIFORNIA TROUT, DELTA CONSERVANCY, ENVIRONMENTAL DEFENSE FUND, ENVIRONMENTAL INCENTIVES, RIPARIAN HABITAT JOINT VENTURE, TROUT UNLIMITED

Background

Among the most pressing challenges in California today are parallel institutional mandates to:

1. Implement wetland, riparian, and floodplain habitat restoration critical to the recovery of imperiled native species;
2. Improve flood protection, water delivery, and water storage infrastructure to withstand a changing climate and growing population;
3. Preserve agricultural lands, food production, and food security to meet the needs of a growing population.

Billions of dollars have been earmarked to restore wildlife habitat and reduce flood risk in California's Central Valley. However, the traditional approach of setting aside lands to "mitigate" for impacts to individual species is unsustainable in a state where 90 percent of the restorable land is under private ownership and the level of mitigation is expected to exceed one million acres over the next two decades. Equally intractable over the long-term are approaches to flood protection that fail to address or maximize their potential role in habitat recovery, or that do not adequately acknowledge and value agricultural lands and landowners as critical components of flood management. California's productive agricultural landscape already supports much of the existing habitat for imperiled species as well as providing de-facto flood protection for urban and rural communities. More habitat and flood protection will be necessary in the future. The agricultural sector has the opportunity to be part of the solution and benefit from doing so. Balancing food production, habitat recovery, and flood protection into the future will hinge on their integration in the landscape and the extent to which that integration is valued and mirrored in historically siloed management approaches and institutions.

The Central Valley Habitat Exchange

The Central Valley Habitat Exchange (CVHE)[20] is a new initiative being developed to more completely valuate the range of environmental benefits provided by agricultural lands through restoration activities and/or changing management, and to promote the reintegration of habitat into California's working landscapes. Taking advantage of the emerging market of habitat credits, CVHE will facilitate a sustainable stream of investment in California's working landscapes by promoting, monitoring, and assisting in the exchange of habitat credits. A habitat credit is a measure of the ability of a land parcel to support a particular species or natural community. The value of the credit is determined by many factors, including the quality of the parcel for the species or community in question, the duration of time the parcel will be in this condition, and the likelihood that the parcel and surrounding landscape will continue to serve this function. Habitat credits offer willing landowners the potential to gain another revenue source and to realize financial benefits from providing high quality habitat that contributes to sustaining our

natural resources. Credits also provide a means for those managing natural resources to recognize and value working agricultural lands as opportunities to more effectively improve the resource base.

The CVHE is anticipated to pilot the Exchange in 2015 at Knaggs Ranch (described in Case 1B). The rice farmers at Knaggs will be compensated for voluntarily creating and maintaining high-quality habitat for waterfowl, salmon, and perhaps other threatened or endangered species.

The CVHE initiative highlights a significant opportunity for aligning human systems with ecosystems. This case assessment, in particular, focuses on how CVHE links institutions and management bodies to improve stewardship of land and natural resources in California.

CONNECTED THINKING

3. Emphasize connected-benefit projects

The development of this approach was initiated with the California Rice Habitat Credit Trading Pilot Program, which has now been folded into the CVHE. The Pilot Program emphasized rice management that was compatible with waterfowl habitat, paving the way for other projects in the Central Valley (e.g., Knaggs Ranch) that are emphasizing connected benefits for agriculture, conservation, and water management. The valuation of habitat benefits provided under the California Rice Habitat Credit Trading Pilot Program, and continued with the CVHE, creates a precedent that can be used to incentivize other projects that align with ecosystem processes and provide multiple, connected benefits. By valuing habitat functionality and flood protection benefits, farmers can receive income to compensate them for any loss of flexibility that results from aligning their agricultural practices with natural processes.

5. Focus on long-term goals versus short-term fixes

While the initial adaptation of rice management practices to provide seasonal wetlands has already seen significant benefits for waterfowl recovery, populations persist at a fraction of their historic abundance. Recovery over the long-term, and for other species, will necessitate a much larger-scale adoption of integrated approaches to conservation and agriculture, allowing the landscape to realize its potential carrying capacity for both. By valuing the benefits to species that agriculture can provide, the CVHE makes an ecosystem-sensitive approach to agriculture more sustainable for landowners. This approach looks for forward-thinking opportunities to design new agricultural practices that attempt to ameliorate impacts of the past's near-sighted practices that so greatly diminished wildlife populations in the Central Valley.

Balancing food production, habitat recovery, and flood protection into the future will hinge on their integration in the landscape and the extent to which that integration is valued and mirrored in historically siloed management approaches and institutions..

Opposite: *Habitat on a farm in the Delta.* Photo courtesy of Matt Grimm, Environmental Defense Fund. *Above: Waterfowl in rice field.* Photo courtesy of California Rice Commission.

Waterfowl in rice field. Photo courtesy of California Rice Commission.

INSTITUTIONAL LINKAGES

1. Move beyond institutional goals and entrenchment

The perception of water supply management, food production, and habitat for wildlife as disconnected has been institutionalized in the separation of the agencies and management bodies concerned with these critical landscape functions. Over time, those institutional divisions have contributed to their respective goals being mistakenly perceived and in conflict with one another. CVHE is both a mechanism for and an example of a more integrated approach to land and resource stewardship. The working group developing CVHE includes state resource management agency representation, the agricultural community, and conservation-focused nongovernmental organizations. By quantifying the habitat value provided by agricultural lands, CVHE will incentivize a management approach for those lands that identifies and prioritizes common goals and actions with multiple benefits.

3. Manage political and economic drivers

The disconnections in our institutional structures for managing agriculture, water supply, and habitat for wildlife, have resulted in political disconnectedness around these areas, as well as debates and conflict over the economic feasibility of addressing all three. Measuring habitat value will create an economic incentive for landowners to simultaneously improve habitat as a way to increase and diversify their revenue while maintaining or even improving agriculture productivity or other land uses. Additionally, resource managers will have a mechanism for increasing and sustaining high quality habitat that is both less costly and less politically charged than off-site single species mitigation or removing land from production.

6. Design and implement approaches to manage the transition from existing to new practices

Public demand fueled by a growing body of science on the loss of habitat and species have led to an array of legislation, policy, and resources dedicated to the recovery of natural communities and habitat for at-risk species. While conservation of natural communities and landscapes in California is motivated by a range of factors, effective implementation of habitat recovery measures has been specifically challenged by the lack of a mechanism to quantify the economic value of gains in that area. Similarly, when agricultural lands in California are developed, the loss is more significant than the simple market value of the crop no longer being produced. Valuating the habitat provided on California's working agricultural lands represents the next stage in our evolution towards a connected landscape, providing landowners with an economic incentive to manage lands for connected benefits, resource managers with an alternative to traditional off-site mitigation, the market with an expanded perspective on the value of agricultural lands, and ultimately a much better environmental return on investment.

GUIDING PRINCIPLES

Implementing Connectivity: Guiding Principles

CRWFS has identified three initial high-priority areas in which we believe the connectivity approach can effect significant change in California's food and water systems:

Connected Thinking

Institutional Linkages

Public and Stakeholder Engagement

For each of these high-priority areas we have developed several principles to help guide assessment of water and food issues, as well as design and implementation of solutions. Guiding principles are best employed by forming them into questions to be considered relative to your project. Guiding questions encourage an exploration of the issue from a strategic level, which helps reorient thinking and enables the discovery of innovative solutions.

Rice grown at Knaggs Ranch. Photo courtesy of Jacob Katz.

CONNECTED THINKING

Connected thinking helps us bridge the silos of our thought patterns, and move from single-issue thinking to whole-systems thinking. By shifting our focus to analyze issues in the context of whole systems and their interconnectedness, we can design solutions that provide connected benefits and avoid unintended consequences. This requires that we increase our understanding of natural systems and the evolving interactions between our ecosystems and human systems over time. It also suggests that we emphasize the need for protection and restoration of our ecosystems in light of our growing human demand for resources.

1. Understand natural systems: Integrated thinking and science-based solutions

A connected approach to water and food supply management links agriculture, species conservation, and water management as integral components of a connected system. It shifts the workings of human systems — in this case, water and food supply systems — within the context of ecosystems. Based on this understanding, we prioritize projects that align with and leverage the processes and infrastructure of the natural environment.

A connectivity approach requires that we understand natural systems better. Existing science and traditional ecological knowledge about the structure and function of natural systems provides a strong foundation for the development of innovative approaches to land use. However, new science is needed that focuses on the nodes of connection between human systems and ecosystems, and integrates those discoveries into land use and water management. A science-based understanding of connectivity is necessary to more effectively engage our human systems within the natural environment, develop whole-systems goals, and design and manage human systems to reach those goals.

Much of the currently available data are inconsistent and challenging to access and interpret. As a result,

Rice harvest at Knaggs Ranch. Photo courtesy of Jacob Katz.

public policy and regulatory decisions are often made with inadequate or misleading information. Improved data access, greater transparency in data sources, and more collaborative interpretation and planning will facilitate a science-based approach to the connectivity of our food and water supply management decisions.

2. Recognize that water, farmland, and habitat are finite resources that depend on each other

As we develop our understanding of the interdependence between water, farmland, habitat, and urban development, we must bring our management decisions for each of these into alignment. Rather than see them as competing land uses, the connectivity approach provides us with a framework to integrate our finite resources into our management practices in order to simultaneously produce food, steward our water and natural resources, and support healthy populations of humans and wildlife.

3. Emphasize connected-benefit projects

Prioritize public investments that generate connected benefits across urban, agricultural, and environmental domains, effectively shifting our resources to address the needs and goals of the whole system rather than one segment of it.

4. Recognize that food is water

We need to shift our collective perspective to recognize that food is water. The way we think about and manage our water supply and quality impacts a wide range of ecosystems outcomes, including our ability to sustain soil health for food production and water availability for all human and ecosystem needs.

5. Focus on long-term goals versus short-term fixes

Institutional planning is generally based on human life cycles, which are relatively short compared to the much longer life cycles found in natural ecosystems. Human systems are designed to respond to immediate needs and emergencies, though often at the cost of a much-needed focus on long-term goals.

In the past decade, California's government has started to change the way it manages natural resources. Government policy is shifting away from its historical focus on siloed resource management and toward a more proactive and holistic approach of integrated resource management. We would like to see this approach include planning for a vision that more closely aligns with the longer life cycles of nature (akin to the Native American principle that actions be sustainable for seven generations) and emphasis on the guiding principle of connected thinking.

6. Avoid unintended negative consequences of past and emerging approaches

Connected thinking and management is needed in response to the unintended consequences and costs resulting from both past and current practices. In order to better anticipate the long-term consequences of today's approaches and solutions, we must prioritize scientific exploration of the connectivity of human systems and ecosystems, and make informed government policies. We believe that if human systems can better mirror the systems of the natural world, we can minimize unintended, negative consequences and achieve greater, more diverse, and sustained benefits with the same or fewer resources.

INSTITUTIONAL LINKAGES

Institutional linkages help us to build bridges across institutional siloes, linking institutional infrastructures, legal processes, information sources, regions, interests, and stakeholder groups. While some progress has been made toward increasing cross-institutional and stakeholder collaboration, this collaboration is needed system wide. Increasing institutional linkages is one of the most critical shifts we need to take. This shift is best supported through strategic initiatives that align the goals of single institutions with the goals of the whole system, while establishing common leadership and management practices and collaboration processes across these institutions. This requires political will, bottom-up and top-down planning, overcoming bureaucratic inertia, and new and evolving policies.

1. Move beyond institutional goals and entrenchment

Historically, institutions at the local, state, and federal level have been designed to fulfill specific resource management functions. Within those institutions, employees have specific roles with specific deliverables that contribute to the institution's mission. We find that this structure inhibits achievement of whole-systems goals that lie beyond the direct missions of individual institutions. Whole-systems goals can only be achieved when cross-institutional collaboration and integration become a high priority, occur at all levels, and are intentionally designed, funded, and implemented. This requires investing in institutional infrastructure redesign and professional development to enable employees to engage collaboratively. Institutional collaborations can be built by engaging in much needed intra- and cross-institutional learning. Existing examples of such learning include coordinated permit efforts, interagency collaboration on groundwater and nitrate issues and dairy digesters, and the California Biodiversity Council.

2. Address conflicting policies and regulations

Both regulatory and nonregulatory state and federal agencies make natural resource management policies and regulations, which at times, conflict with or are duplicative of those made by other departments or agencies. This can result in 'turf' issues among agencies and frustration for those implementing the policies or regulations. Many agencies have begun to recognize these issues, and are taking leadership to proactively address them. Institutions that are guided by whole-systems goals and are regionally linked across stakeholder groups, are far more likely to avoid conflicting policies and regulations.

3. Manage political and economic drivers

Political and economic decisions should factor in the needs of the natural system. One way to achieve this is to modify existing regulations to more equitably distribute water to achieve connected benefits for human systems and ecosystems, rather than prioritizing benefits to single crops or regions. A way to incorporate the value of ecosystems into our political and economic frameworks is through the valuation of ecosystem services.

4. Shift from 'one-size-fits-all' solutions to collaborative, regionally-appropriate, whole systems strategies

The connectivity approach invites the development of long-term, statewide strategies and guidelines, as well as local and regional approaches and initiatives. Whole-systems goals should establish a general direction and allow flexibility in implementation.

5. Assess and manage unintended consequences

Unintended consequences stem largely from single institutions setting policies, regulations, and guidelines in isolation from other institutions. A more recent focus on interagency coordination has alleviated this to some degree. Continued and improved linkages between institutions and related disciplines are needed to assess potential consequences of new solutions and minimize negative repercussions. This includes cross-institutional and cross-disciplinary transparency and alignment with whole-systems goals.

6. Design and implement approaches to manage the transition from existing to new practices

A long-term transitional management plan is required to make the shift from existing management practices to implementing a more connected approach. These plans need to be designed and managed with cross-institutional input and buy-in as well as tools, such as executive orders or legislative mandates, to reinforce them. A transitional plan forecasts challenges and proactively seeks to resolve them.

PUBLIC AND STAKEHOLDER ENGAGEMENT

The overall success of the connectivity approach depends on the public's support. Our efforts must effectively connect the public to the critical issues we all care about — water and food supply sustainability here in California. We define the public as anyone who consumes water – in other words, 'us' rather than 'them.' Many water users are also voters, whose role in influencing initiatives and related funding is important to the process. Ultimately, we all face the same water-related challenges, and their consequences.

Our goal is to effect a shift in perspective from the consumer mind-set to one that is participatory and empowers the individual user to help steward our water resources. To support this shift, we need to increase water resource literacy, provide better access to accurate information, and raise awareness of our individual contributions to California's water resource issues. Opportunities to engage in decision-making processes designed for public participation are also a key factor.

1. Participate versus consume

Accountability increases when people see themselves as an integral part of a larger system. Thinking of ourselves as consumers inherently separates us from the systems and processes that generate the services and products upon which we depend. When we see ourselves as participants in a connected system, we are more aware of both our positive and negative impacts to the system and how it affects our own lives. Initiatives that encourage recycling or allow us to calculate our water and ecological footprints help make these connections and shift the consumer mindset to one of participation.

There is a need to stimulate greater connectivity between the public and the natural environment. This includes a) increasing the public's understanding of water resource issues, b) raising awareness of the fact that food production requires a large amount of water, and c) drawing the public's attention to successful local projects in which they can get involved.

2. Public action from the ground up

Good government embraces bottom-up, grassroots initiatives that generate creative, collaborative, cross-institutional approaches and solutions. Illustrating how collaboration works inspires others to get involved and conveys that there are actions we can take to help address local and regional issues. As more people understand the challenges and participate in solutions, it instills a sense of ownership, which, in turn, generates collective responsibility of action.

3. Communicate with the public

We need to become better at telling the story about food and water in California, taking into account the perspectives, needs, and values of the public. This includes relating these topics to our personal and family lives, our health, jobs and wealth, our businesses and overall economic welfare, as well as the health of the environment. Shifting the language from 'them' to 'us' helps shift the perspective.

4. Increase awareness and effectiveness of educational programs

A number of educational programs on water and food supply are currently available. However, existing educational programs often fail to reach the public due to a range of reasons including a lack of connection to real-life scenarios, limited hands-on learning activities, and failure to effectively address language barriers. To increase awareness about our food and water supply issues, educational programs need to be more accessible to the public and more vividly demonstrate the circumstances and consequences of our water consumption at home and on the farm.

ENDNOTES

1. http://aginnovations.org/roundtables/crwfs/action/#Connectivity
2. CDFW was formerly the CA Department of Fish and Game
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7. Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life History of Fall-run Juvenile Chinook Salmon, Oncorhynchus Tshawytscha, in the Sacaramento-San Joaquin Estuary, California. Pages 393-411 Estuarine comparisons (V. S. Kennedy, ed.). Academic Press, New York, NY; Snider, B. and R.G. Titus. 2002. Lower American River Emigration Survey, October 1998- September 1999. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program, Technical Report No. 02-2; Jeffres, C. A., Opperman, J. J., & Moyle, P. B. (2008). Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes, 83(4), 449-458; Sommer, T., Harrell, B., Nobriga, M., Brown, R., Moyle, P., Kimmerer, W., & Schemel, L. (2001). California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries, 26(8), 6-16.
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9. http://pacinst.org/publication/integrated-regional-water-management/
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20. http://aginnovations.org/images/uploads/CentralValley_HabEx_factsheet_04.pdf

The California Roundtable on Water and Food Supply is a project of Ag Innovations Network, a nonprofit organization dedicated to helping stakeholders solve systemic issues through effective collaboration.

info@aginnovations.org | 707.823.6111 | www.aginnovations.org/roundtables/crwfs

Cover Photo: Waterfowl in rice field. Photo courtesy of California Rice Commission.