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Fall Sacramento Meeting Highlights

by Charles M. Burt, Conference Co-Chair, Irrigation Training & Research Center, San Luis Obispo, California

The Theme of the October 2017 USCID Conference in Sacramento was *Finding the Balance — Improving Infrastructure, Water Management, and the Environment in a World with Limited Funding and Ample Regulations*.

The Conference did indeed get close to finding the perfect balance for content and organization. Some key numbers:

Attendees: 215

Exhibits: 23

Poster presentations: 32, including 30 Cal Poly students

Planning committee members: 22, from seven states composed of consultants, government employees and irrigation district personnel

But it was much more than the numbers. There was visible enthusiasm by

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Cal Poly student Aaron King with his poster.

2017 Scholarship and Awards Announced

Brian Wahlin presents check to Karen Fritch.

Karen Fritch, an undergraduate environmental engineering major at Washington State University, received the 2017 USCID/Summers Engineering Scholarship.

Grant G. Davids was named the recipient of the USCID Service to the Profession Award. **W. Martin Roche** received the USCID Merriam Improved Irrigation Award in recognition of his outstanding service to USCID.

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Phoenix in 2018

USCID's **11th International Conference on Irrigation and Drainage** will take place in Phoenix, October 16-19. *Water Reuse and Non-Traditional Water Sources for Irrigated Agriculture* is the theme. The Water Research Foundation is a Cooperating Organization.

Brian T. Wahlin, WEST Consultants, Inc.; and **Eduardo Bautista**, Agricultural Research Service, USDA, will serve as Conference co-chairs.

As part of the focus on water reuse and non-traditional water sources, discussions during the Conference will also address groundwater recharge and environmental concerns.

For more information, visit www.uscid.org/18azconf.html.¤

President's Message

I recently had the honor of being elected Vice President of ICID. One of the first duties for me was to represent ICID at the **Water for Food International Forum**, which was held at the World Bank in Washington, DC, on January 29-30, 2018. The theme was *Farmer-Led Irrigated Agriculture: Seeds of Opportunity.* There was a special focus on Africa. It was hosted by the Robert B. Daugherty Water for Food Global Institute and the World Bank Water Group. The Forum was attended by approximately 200 participants from more than 30 countries.

Prior to attending this International Forum, I was not very familiar with many of the issues surrounding farmer-led irrigated agriculture, or smallholder farmers. Attending this Forum gave me a new perspective on the challenges and difficulties that these farmers face, particularly in Africa. There are an estimated 41 million farmers in Africa that have farms smaller than 2 hectares. While very smallholder farms will continue solely to meet household needs, there is clearly an opportunity for many smallholder farms to become profitable businesses. This can only occur if they are well-integrated into effective market-driven value chains. In addition, production on these smallholder farms

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Inside . . .

USCID

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The United States Committee on Irrigation and Drainage is a National Committee of the International Commission on Irrigation and Drainage.

USCID

Mission Statement

The Mission of USCID is to promote progressive and sustainable irrigation, drainage and flood control practices in support of food and fiber production and public safety, recognizing that sustainability embodies economic, social and environmental goals.

USCID Newsletter and Membership

The *USCID Newsletter* is published in Winter, Spring and Fall for USCID Members. News items and technical articles of interest to the irrigation community are invited. Membership information is available on the USCID website.

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- American Academy of Water Resources Engineers
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ICID News and Activities

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Wahlin Elected ICID Vice President

During the 23rd ICID Congress and 68th International Executive Council Meeting held in Mexico City last October, **Brian Wahlin** of WEST Consultants was elected to serve as Vice President of ICID. He is the first Vice President from the United States since 2008, and will serve a three-year term. Wahlin is one of nine ICID vice presidents. The others hail from the Netherlands, the United Kingdom, Morocco, Russia, Pakistan, Nepal, Japan and India.

As a Vice President, Wahlin is a member of ICID's Permanent Committee on Strategy and Organization and will undertake issues related to strategic planning for ICID. As the only Vice President from the Americas, Wahlin will be responsible for promoting cooperation among the various ICID National Committees throughout North and South America.

Brian Wahlin serves as a session chair during the Mexico City Congress.

The Mexico City Congress was inaugurated by Mexico's President Enrique Peña Nieto. Attended by more than 832 delegates from 35 countries, the Congress theme was *Modernization of Irrigation and Drainage towards a New Green Revolution*. The next Congress will take place in Sydney, Australia, September 22-24, 2020.¤

Saskatoon to Host ICID in 2018

The 69th International Executive Council Meeting and Regional Conference will take place in Saskatoon, Saskatchewan, Canada, August 12-17, 2018. The Conference theme is *Innovative and Sustainable Agri-Water Management: Adapting to a Variable and Changing Climate.*

Rebecca Shortt, Ontario Ministry of Agriculture, Food and Rural Affairs, invites USCID Sacramento Conference participants to attend the Saskatoon ICID meeting.

Saskatoon is in the heart of the Canadian prairies, where agriculture and the agri-food sectors drive the economy. Saskatoon is home to world class agriculture research and education institutions that support sustainable innovations in agriculture.

Several pre- and post-meeting tours will be offered, featuring irrigated agriculture sites in Saskatchewan and Alberta.

There will be an exhibition held in conjunction with the meeting; reservations for exhibit booths are being accepted now.

The deadline to receive the early registration fee is May 15. For more information, visit https://icid2018.org.¤

Associate Editors Invited

ICID is seeking several new associate editors for *Irrigation and Drainage*, the Journal of ICID. The Journal is a prestigious, peer-reviewed publication, publishing original papers on scientific, engineering, environmental and socio-economic issues associated with irrigation and drainage. It is a rich resource of reference to professionals, engineers, researchers, university professors and students of irrigation, drainage, and agriculture disciplines. The Journal is published in five issues per volume and is also now available online.

In an effort to maintain the quality of the Journal and speed up the review process and stay competitive with similar journals in the field, ICID is attempting to increase the number of associate editors. This is a great service opportunity and an excellent way to stay current on cutting edge irrigation and drainage research. The time commitment for an associate editor would involve approximately three to four hours per month, and would consist primarily of handling the peer review for two to three papers. This involves reading the paper and then selecting appropriate reviewers from the ICID reviewer database. Please feel free to contact the Joint Editor of the Journal, **Kristoph-Dietrich Kinzli** (kkinzli@mines.edu) to express interest in an associate editor position, or if you have questions.¤

Interaction Between Groundwater and Surface Water: Water and Fisheries Management Issues and Challenges

by Steve Macaulay, P.E., Senior Consultant, Geosyntec Consultants, Snohomish, Washington; and Bob Anderson, LHG, Principal Hydrogeologist, Geosyntec Consultants, Seattle, Washington

Editor's note: The following paper was presented during the recent USCID Conference in Sacramento, California.

Abstract

This paper addresses the water management issues and challenges related to a key portion of California's new groundwater management law: the need to manage groundwater resources to minimize impacts to streamflow resources.

California's 2014 Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as the management and use of groundwater without causing specific "undesirable results." One such undesirable result is defined as:

Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Meeting this new requirement will involve (1) judgment (what do "significant" and "unreasonable" mean?), (2) sufficient technical understanding of groundwater — surface water connections in each basin, and (3) adequate data on groundwater levels, stream flows and stream resources to form the basis of water management decisions.

Groundwater interconnections with stream systems have important implications to water and fishery managers and will need to be addressed in many groundwater sustainability plans. The consequences of SGMA actions to water and fishery resources will be potentially significant. It is essential to have a combination of both technical and policy coordination to address specific issues in the various groundwater basins. A long-term view is essential to assuring that water managers, technical specialists, regulatory agencies, and local governments establish effective decision processes and stakeholder engagement processes to design and implement their Groundwater Sustainability Plan.

Introduction

SGMA Legislative Background

California Governor Jerry Brown's administration supported development of the three bills that collectively became SGMA as a continuation of the Governor's January 2014 California Water Action Plan.[1] Action 6 of the Water Action Plan was to "Expand water storage capacity and improve groundwater management." For 20 years beginning in the early 1990s, the California Legislature passed a number of bills that guided voluntary actions at the local level to plan and manage groundwater resources. In addition, largely in response to the State Drought Water Bank in the severe drought of the early 1990s, a number of counties passed ordinances that sought to regulate groundwater extractions to the extent such pumping directly or indirectly supported marketing of surface water supplies in their counties to other regions of the state. While there are examples of collective efforts to put more focus on groundwater management, in most cases there were no requirements to manage groundwater in a way that promoted long-term sustainability of surface and groundwater resources. Adjudicated basins, where a basin has been in overdraft and local groundwater users petitioned the courts for engagement, have had some success in establishing a balance between surface and groundwater uses.

Land use has played a pivotal element in the long-term trend of depleting groundwater supplies in both urban and agricultural areas. The impacts of land use on groundwater supply has been magnified by a number of factors including drought (1987-1994 and 2011-2015), declining reliability of a number of surface water supplies, changes in agricultural water use, and a concern about losing the physical connection between streams and groundwater in some areas of California. By the early 2000's these concerns were shared to some degree by a wide range of water users, environmental groups and the public. This came to a head in the spring and summer of 2014, in the fourth year of a severe drought. The Association of California Water Agencies had earlier developed a new conceptual model for groundwater management that had local agencies in control with support by state agencies. In addition, key environmental groups, and in particular The Nature Conservancy, took a direct interest in legislative proposals and were involved in legislative negotiations.

Following many months of negotiations, the Legislature passed three separate bills that were signed by Governor Brown in September of that year.

What SGMA Says and Why

SGMA actions by groundwater sustainability agencies (GSAs) are driven by the six "undesirable results" set forth in the law.[2] These are found in the sidebar on page 6.

Appropriate to this paper is the 6th undesirable result. This interconnection

SGMA Six "Undesirable Results"

(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon.

(2) Significant and unreasonable reduction of groundwater storage.

(3) Significant and unreasonable seawater intrusion.

(4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.

(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

of surface water and groundwater is also addressed as a new factor in assessing basin priorities (California Water Code Section 10933), "...including adverse impacts on local habitat and local streamflows."

DWR's March 2015 Draft Strategic Plan notes that one key outcome of SGMA is that "...Surface water and groundwater are managed as "a single resource" to sustain their interconnectivity, provide dry season base flow to interconnected streams, and support and promote long-term aquatic ecosystem health and vitality."

The law provides that each local designated Groundwater Sustainability Agency (GSA) develop its own groundwater sustainability plan, consistent with regulations adopted by DWR. Such regulations allow each GSA to evaluate the potential for "undesirable results." with broad public input as part of the process for developing its Groundwater Sustainability Plan (GSP). It will be up to the GSP to address the nature of the terms "significant" and "unreasonable" as they apply to all undesirable results.

Initial Implementation

Throughout 2015, 2016 and into 2017 DWR developed required SGMA implementation regulations and additional "best management practices" (BMPs) guidance documents. The regulations pertinent to this paper are those regulating the development of GSPs.[3] These regulations require addressing of groundwater elevations, the identification of interconnected surface water systems and trends in depletion of those systems, groundwater-dependent ecosystems, a complete water budget, and other requirements that either directly or indirectly address the "undesirable result" of depletion of surface water systems.

Five BMPs were developed: (1) monitoring protocols, (2) monitoring, (3) hydrogeologic conceptual models, (4) water budget, and (5) modeling.[4] To a large extent the BMP documents provide additional guidance supplemental to the GSP regulations. Most of the BMP documents addressed the connection between surface water and groundwater in some manner, including this statement from the Water Budget BMP:

> *Unless additional inflows or supplies are developed, increases in groundwater extraction may eventually result in a hydraulic disconnection between the surface water and groundwater systems in basins where these systems are currently interconnected. Groundwater systems that are disconnected from the surface water system will still receive recharge from the surface water system. However, all further extraction from the groundwater system may be largely balanced through a decline of groundwater in storage and/or a reduction of subsurface outflow from the basin over time.*

More on this topic is addressed in the following sections.

The Interaction Between Surface Water and Groundwater

GSPs will be required to demonstrate a good understanding of physical interactions (including short-term vs. long-term considerations) between groundwater and surface water based on data and provide predictive analyses at a sufficient resolution and accuracy to enable management policy and action.

Nature of Physical Interaction

The physical nature of groundwater surface water interaction is deceptively simple, yet difficult to quantify and manage. It all starts with elevation (or groundwater "head" in hydrogeology parlance). When groundwater head adjacent to a surface water body is higher than the water surface elevation, groundwater will tend to discharge to the surface water. In this case, a surface water body is "gaining" water from groundwater. When groundwater head adjacent to a surface water body is lower than the water surface elevation, surface water will tend to discharge (or seep) to the groundwater. In this case, a surface water body is "losing" water to groundwater. While the head differences govern whether a system is gaining or losing, the rate and volume of water flowing between the two is a function of many other variables and processes. Of course, the rate and volume of this interaction is of most interest to water managers. The variables that control rates and volumes include the physical properties of the stream bed and the aquifer, the complexity of the stream channel and groundwater flow patterns, the seasonality of the system and the time frame over which rate and volume calculations are carried out.

The following figures (U.S. Geological Survey Circular 1139[5]) have been used extensively to describe the interconnections — or lack of connections in many circumstances — between surface water and groundwater. These figures seem the most relevant to SGMA as GSAs deal with the interconnection issues. Figure 1 shows the characteristics of a gaining stream, whereby streamflow is augmented by groundwater contributions. Figure 2 shows the characteristics of a losing stream, whereby streamflow is reduced by water loss into the aquifer. In both these cases there is a physical connection between the stream and the aquifer, controlled generally by groundwater elevations.

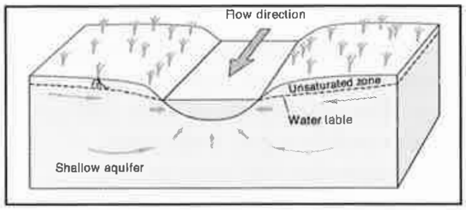


Figure 1. Gaining Stream.

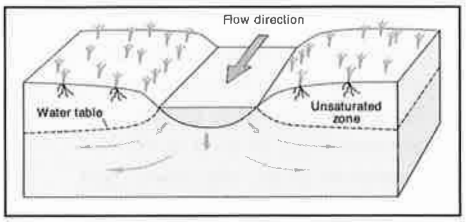


Figure 1. Losing Stream.

Figure 3 depicts the circumstance where there is no physical connection between the stream and the aquifer. Under such conditions water from the stream enters an unsaturated zone: groundwater does not contribute to streamflow, but stream losses contribute to aquifer storage.

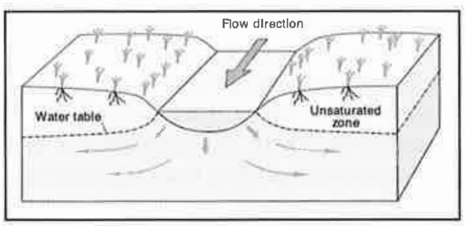


Figure 3. Disconnected Stream.

Modeling Tools

While it is possible to directly measure the rate and volume of water moving between groundwater and surface water, it is not common and often very difficult. Therefore, modeling tools are necessary to both analyze historical conditions and to predict future conditions. Time is an important integrating variable in these models and can create a dilemma for both practitioners and stakeholders. Standard hydrologic and engineering models of surface water systems are typically developed to capture processes on a daily time scale (often minutes in the case of storm flows). Accommodating the longer-term hydraulics of groundwater inflows/outflows in these models is often awkward. Conventional models of groundwater flow, on the other hand, are typically developed to capture monthly or annual processes and often cannot accommodate the fine-scale time frame of surface water flows (especially flood flows).

While there has been "convergence" in the technical coupling of groundwater and surface water models, the issues of model accuracy and precision are still relevant in selecting technical approaches to specific problems or settings. While these new models have improved the precision of calculations, the accuracy of model predictions are still founded on first principles, availability of data, and objectives of the analysis.

Planning Considerations

Definitions and Questions

SGMA carefully attempts to emphasize local management leaves open a number of issues for resolution in the context of stakeholder discussions.

- Avoiding a blanket prescription of specific sustainability goals;
- Allowing for local discussion and definition of what constitutes "reasonable and significant" with respect to undesirable results; and
- Providing a baseline for evaluating undesirable results, but stating that *"The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015."*

DWR provides clarification about interconnectivity in the Groundwater Sustainability Plan Emergency Regulations adopted in June 2016. These Emergency Regulations define two terms that will guide development of GSPs in the content of groundwater and surface water interconnectivity (Article 2, Definitions):

- *(m) "Groundwater dependent ecosystem" refers to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.*
- *(o) "Interconnected surface water" refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.*

SGMA will generate a number of questions and concerns that undoubtedly will arise regarding the issue of interconnected groundwater and surface water. The definitions provided by DWR in and of themselves generate some fundamental questions:

- Groundwater dependent ecosystems appear to be defined as aquatic ecological communities that are in a gaining condition (where groundwater is "emerging" to the ecosystem). Does this mean that ecosystems in "losing" condition (where surface water is discharging to groundwater) do not need to be analyzed? There are likely to be situations where groundwater pumping would increase the amount of water that is discharging from surface water to groundwater, possibly impacting ecological communities.
- Interconnected surface water is defined as surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. Here, the definition of the baseline condition comes into play. Does this mean that surface waters that had become "disconnected" from groundwater in 2015 (perhaps temporarily) are exempt from analysis? Does this exempt surface waters that had become "completely depleted" in 2015?

These are important framing questions that GSAs will need to discuss and resolve in the context of defining sustainability goals and setting thresholds for management that do not cause significant and unreasonable undesirable effects. In a more technical context, GSAs will be considering questions such as:

- Should streamflow effects be expressed as a percentage of streamflow or should other ecologic and hydrologic metrics be considered, such as stream depth, statistical variability, or weighted usable habitat area?
- Should streamflow effects be analyzed in a steady state or transient analysis? Transient (i.e. time-varying) analyses are valuable

because they can address both seasonal-scale lag time of pumping effects from a well (or series of wells) and cumulative carryover effects on the entire system from year to year.

- How should issues of accuracy and precision (both spatial and temporal) be addressed for surface water analysis as compared to groundwater?

These issues, and others, will influence how analyses in GSPs are integrated and interpreted by both water managers and water users.

Fisheries Management

Fishery agencies (California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Natural Marine Fisheries Service / NOAA Fisheries) are tasked with managing actions to protect fishery resources. Historically such actions have included regulatory restrictions on release of water from reservoirs, restrictions on surface water diversions, and other actions to protect or improve habitat conditions. In some cases, such regulatory restrictions are embodied in regulatory actions by the State Water Resources Control Board, through terms and conditions on permitted surface water rights. To date, most restrictions have been driven by the California Endangered Species Act, Federal Endangered Species Act, California Environmental Quality Act (CEQA), and National Environmental Policy Act (NEPA), tailored to each species listed under these Acts and the current conditions of species populations, habitats and threats. For example, the National Marine Fisheries Service Final Recovery Plan for winter-run, spring-run and steelhead (NMFS, 2014) contains extensive analysis and actions addressing key life stages and ecosystem indicators.

Habitat restoration and fish passage improvements are important elements of most fisheries management programs and are (relatively speaking) simple to propose and develop. In-stream flow provisions are also important aspects of fisheries management, but can be more difficult to propose and develop because of water rights, which have an established legal standing that can be very complex to resolve in the context of competing beneficial uses.

An early indication of how these fishery agencies might approach the interconnection issues is review of what SGMA describes as "Alternative Submittals" (hereinafter referred to as Alternative Plans). Alternative Plan requirements are set forth in SGMA[6] and had a due date of January 1, 2017. This provision is in SGMA presumably to allow early compliance with aspects of SGMA requirements for already well-managed basins, in lieu of a SGMA GSP. The abbreviated general requirement for Alternative Plans is to show "An analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years." Alternative Plans were subject to a public comment period that ended in April 2017. Although DWR has not specified its timeline for reviewing these alternative plans, the intent is to review them in accordance with the requirements of a SGMA GSP. Of the 24 Alternative Plans submitted to DWR, six of them received comments related to surface water depletion and fisheries. Both the California Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NMFS) submitted comments on Alternative Plans.

Both CDFW and NMFS asserted that the analyses presented in several of the Alternative Plans were not sufficient to demonstrate the absence of undesirable effects. This theme was echoed in other comments. Lack of a surface water/groundwater model is also suggested as a limitation to the analyses. NMFS also expressed concern in one instance that protection of fisheries was not explicitly stated as a management goal and that some management strategies did not leverage existing tools developed to address fisheries protection. It is likely that any basin with established or sensitive aquatic ecosystems is likely to be scrutinized by fisheries agencies with respect to surface water depletion and potential effects of the GSP. However, it is not clear whether perceived deficiencies with respect to fisheries management in a GSP will become a basis for rejection by DWR.

Basin Management

GSPs will become another layer in an already complex overlay of water supply, water quality, land use, and economic development plans that are constantly being developed, revised, or updated at the local, state and federal level. The preparation of each GSP will involve public input, with some expectation that this process will generate extensive dialogue among a wide variety of interests. For those basins where the interconnection is at issue, the water management implications could be extensive. The implications of GSP actions will depend on the technical nature of the interconnections as well as the management goals, objectives and timelines established in the GSP. Similar to undesirable effects related to water quality, the difficulty will be in distinguishing SGMA-driven groundwater supply issues from other applicable planning and regulatory efforts. GSPs should not "re-invent the wheel."

Successful GSP implementation will require a robust and clearly described basin water balance to allow predictive tools to forecast the adequacy of possible water management actions that prevent undesirable effects related to streamflows. There will undoubtedly be uncertainties regarding both the baseline condition and the effects of proposed management actions. In many cases, adequate water balance information and predictive tools may not be available in many initial GSPs submitted in 2020/2022, and stakeholders should not expect full resolution of issues in the first iteration of planning. As DWR has indicated, this is a marathon, not a sprint. Even so, it is possible that some early water management actions related to streamflow management will be proposed in some basins.

One of the more obvious GSP management actions pertaining to streamflows would be related to siting and extraction limitations of wells near stream systems. How such water management actions would be implemented will test the GSP's institutional structure as well as the collaborative framework of groundwater users in the basin. GSPs are also required to address groundwater replenishment actions, to the extent that additional replenishment can help establish a sustainable groundwater balance and address all categories of "undesirable results". A concern raised by several water managers early in SGMA implementation (Personal Communication, May 2015) is that additional diversion of stream flood flows to replenish groundwater basins could be restricted by fishery agencies to protect stream habitat and maintain hydrologic function during higher flow periods. In discussions at that time, the frustration by water managers is that they might be prevented from protecting future stream flows through additional replenishment, in order to protect then-current stream flows. This concern seems to be grounded in the current regulatory framework that focuses on current-year fisheries conditions and does not necessarily consider implications to future conditions. The concept of adaptive management may prove to be crucial in addressing these issues and will require collaboration and trust among all stakeholders.

The Long View of Impacts is Important

Whether it is water or fishery management actions, the long view is essential. SGMA requires that groundwater basins be sustainable, which is a long-term concept. While designing GSP actions to avoid undesirable results is essentially a compliance concept, it also should take the long view into account, particularly with respect to surface water depletion as the effects of compliance or non-compliance with regards to fisheries and aquatic ecosystems do not appear immediately. This will require a different approach to management, particularly by stakeholders and agencies that typically respond and take actions year-by-year.

One example illustrates the dilemma facing water users and fishery agencies: management actions that divert additional surface water resources to replenish groundwater and prevent further impacts to stream resources. This potentially conflicts with the practice of fishery agencies to manage resources on an annual basis, looking primarily at impacts of potential water management actions on fishery resources in the year that it occurs. This historical approach could make it difficult for water agencies to acquire water rights to divert additional surface water unless and until the fishery agencies and the State Water Resources Control Board (California's agency regulating surface water rights) more clearly recognizes how SGMA's dual objectives of replenishing groundwater and avoiding stream resources impacts will work together. In many cases, the potential impacts of streamflow diversion on current fish populations will need to be weighed against the potential benefit to future fish populations from enhanced groundwater conditions.

If adequate institutional protections can be put in place, it seems appropriate that additional surface water diverted in wetter years and during spring freshets to replenish groundwater could be viewed by all parties as one action helping to avoid future stream resource impacts. If properly designed, the range of variability and hydrologic function of a stream system can still be preserved while putting more surface water to work in the form of groundwater recharge. The idea is to establish a new equilibrium over time that benefits both groundwater and surface water and supports all beneficial uses. This is what we refer to as the "long view."

Implications of Groundwater Sustainability Plans

As California begins to craft GSPs in many regions and institutional settings across the state, the implications of these plans on both the policy and technical approaches to water management will not be known for years, or perhaps decades. By more explicitly including groundwater into overall management considerations, the scope of watershed-scale hydrologic analysis will increase. SGMA's emphasis on local management responsibility indicates an effort to establish a framework for sustainable management in a local context, which creates opportunities and challenges.

- The ability of stakeholder groups to work together collaboratively and constructively during GSP development will "set the tone" for both implementation and the long-term outcomes in these basins.
- The ability of technical staff and consultants to clearly and concisely explain both the complexity and simplicity of various hydrological processes will shape attitudes and create intuition on the importance of groundwater
- The ability of stakeholders to resolve real and/or perceived water right issues through the GSP process could create new ways to address water management conflict that do not rely on courts.

There are a number of open technical (and to some extent policy) issues that will need to be addressed as GSPs are developed. In addition, it will be essential to see how DWR applies its GSP regulations, with the first opportunity DWR's review of "alternative plans" which are required to be in substantial compliance with the topics covered in the GSP regulations. The authors expect some initial DWR reviews of alternative plans to be released in the first half of next year. The open technical issues include, but are not limited to:

- Judging the adequacy of forecasting tools for sustainable groundwater management, recognizing that this is likely to vary from basin to basin and improve over time
- Judging when data is adequate to support modeling forecasts of sustainable groundwater conditions
- Determination of when a GSP is complete enough to meet the requirement of addressing the surface water interconnection issues and satisfy issues pertaining to aquatic ecosystems and fish habitat

Conclusions

Groundwater interconnections with stream systems, as they will need to be addressed in many groundwater sustainability plans, have important implications to water and fishery managers. Since the consequences to water and fishery resources are so important, it is essential to have a combination of adequate data, water balance and predictive tools in place before resource actions are taken. GSPs will need to address the groundwater / surface water interconnection "undesirable result" category (and in fact, each of the six categories) in sufficient detail to determine which are "significant" and "unreasonable" enough to cross a threshold of importance, based on a combination of available data and tools as well as SGMA regulations and DWR Best Management Practices documents.

A long-term view is essential to assuring that groundwater basins are sustainable, and "undesirable results" are avoided. We should not expect full resolution of all issues in the initial GSPs, and it may take several GSP iterations to fully address all management issues (both water and fisheries) to assure sustainability. SGMA has a 20-year implementation horizon for achieving sustainability, basin-by-basin, with the anticipation that implementation will be phased as data, tools and actions are developed. Further, each GSP will need to show that it will achieve sustainability over the next 50 years. The door needs to be open for early management actions. This has implications to water managers, regulatory agencies, local government and the decision process to be put in place by groundwater sustainability agencies to implement groundwater sustainability plans.

Endnotes

[1] California Department of Water Resources. Groundwater Sustainability Program, Draft Strategic Plan, March 2015, page 11.

[2] California Water Code Section 10721(w).

[3] http://www.water.ca.gov/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf

[4] http://www.water.ca.gov/groundwater/sgm/bmps.cfm

[5] U.S. Geological Survey Circular 1139, "Ground Water and Surface Water, A Single Resource", Denver, Colorado 1998.

[6] California Water Code Section 10733.6.

References

DWR, Sustainable Groundwater Management web page (http://www.water.ca.gov/groundwater/sgm/)

DWR, GSP Emergency Regulations, June 2016.

DWR, BMP 1: Monitoring Protocols, Standards, and Sites

DWR, BMP 2: Monitoring Networks and Identification of Data Gaps

DWR, BMP 3: Hydrogeologic Conceptual Model

DWR, BMP 4: Water Budget

DWR, BMP 5: Modeling

State of California, various sections of California Water Code

U.S. Geological Survey Circular 1139, "Ground Water and Surface Water, A Single Resource", Denver, Colorado 1998¤

Sacramento (continued)

attendees from the beginning to the end. The topics were nothing short of interesting, and this was definitely not a sit-and-listen Conference. Debate and clarification among panel members and between the audience and presenters was cordial and active.

Tuesday Field Tour

As usual, the Conference began with a field trip to Yolo County Flood Control and Water Conservation District. District Manager **Tim O'Halloran** and his staff provided an excellent overview of their unique SCADA system and automation progress, while also covering the unique governance of the district as a county agency. Of particular interest was the involvement of the district in groundwater management and conjunctive use — a strong theme throughout the Conference. The tour started at the District's office with briefings by Assistant General Manager Max Stevenson and SCADA Operations Supervisor Tim Ireland. The group then proceeded to the Winters Canal, a 100-year-old, 16-mile-long canal that has recently been retrofitted with 25 automatic level/flow control gates. Sites visited included the Fredric Flume and the School House Check.

Technical Sessions

Three main themes throughout the Conference involved the complexity of managing surface water and groundwater supplies as a whole, while attempting to improve the environment and still retain an adequate and economical supply for agriculture. The panel and papers were organized to provide an integrated view of these themes.

Thirty-six papers or panel participants explicitly dealt with water balance and conjunctive use issues. These presentations addressed real and current problems, along with solutions.

Six special sessions were provided on the "technical basics" of Understanding, Completing, and Implementing State and Federal Water Management Plans. The targeted audience was districts, agencies, and consultants. Sessions were intended to fill in the blanks on technical issues encountered in developing various water management plans. Presenters included **Hicham Eltal** (Merced ID) who discussed objective based/benefits of water management plans; **Bryan Thoreson** (Davids Engineering), on water balances, **Bekele Temesgen** (California DWR) on ET approaches and DWR plan submission; **Stuart Styles** (Cal Poly ITRC) on measuring surface inflows/outflows to a district, **Charles Burt** (Cal Poly ITRC) on groundwater, and **Gary Kienlen** (MBK Engineers) on Efficient Water Management Practices.

A special topic dealt with the Bureau of Indian Affairs (BIA) irrigation projects encompassing more than 700,000 irrigated acres in the west — a little-known but important aspect of western U.S. irrigation. Presentations were provided regarding the Ute Indian Water Rights (Lee Baxter, USBR), separating livestock water from irrigation water in Duck Valley (Reggie Premo, Duck Valley Indian Reservation), rehabilitation of laterals of the Gila River Indian Community (David Phelps and Bill Eden, Stantec and P-M Irrigation Project), and overall funding challenges of BIA (Charles Burt, Cal Poly ITRC).

Perhaps one of the more interesting subjects was the huge variation between states in how groundwater is dealt with in state water law. **Laura Schroeder** (Schroeder Law Offices) succinctly summarized groundwater law in the western U.S.; **Ralph Scanga** (Upper Arkansas Water Conservancy District) described the complexity of inter-state relationships, and Rebecca Shortt (Ontario, Canada) provided a view of Ontario water governance.

Steve Macaulay and Bob Anderson (Geosyntec Consultants) and others addressed the difficulties and benefits associated with groundwater/surface water modeling. They stressed the need for using good judgment and overall understanding, rather than relying only on model results.

Friday Field Tour

The Conference ended with a full-day field trip to irrigated areas of the Sacramento Valley. Rice is a major crop in the Valley, but the area is quickly seeing crop diversification. Various

Exhibitors

- Advanced Drainage Systems
- Aqua Systems 2000 Inc.
- Clipper Controls
- George Cairo Engineering, Inc.
- HUESKER, Inc.
- Hydro Component Systems, LLC
- Irrigation Training & Research Center
- KISTERS North America, Inc.
- MACE, an In-Situ Company
- Natal Energy Inc.
- REDtrac LLC
- Rubicon Water
- Sage Designs, Inc.
- Sierra Controls, LLC
- SonTek
- Stevens Water Monitoring Systems, Inc.
- Thompson Pipe Group
- TruePoint Solutions
- Watch Technologies
- WaterMaster
- WEST Consultants, Inc.
- Willowstick Technologies
- YOOIL Rubberdam Engineering

Sponsors

- California Department of Water Resources
- Davids Engineering, Inc.
- GEI Consultants, Inc.
- Hydro Component Systems LLC
- MBK Engineers, Inc.
- Provost & pritchard Consulting Group
- WEST Consultants, Inc.
- WaterMaster

agencies have learned to work cooperatively in developing win/win meaningful programs to enhance fish, waterfowl and other wildlife habitat while simultaneously improving irrigation.

Conclusion

The integrated themes of the presentations and the practical knowledge imparted by the speakers and moderators kept the conference moving from beginning to end. Special thanks go to Thad Bettner, Manager of Glenn-Colusa Irrigation District, who was Conference Co-Chair and responsible for many final details required to have a very successful Conference.¤

Awards and Scholarship (continued)

Scholarship recipient Karen Fritch will graduate in the spring of 2019 with an Environmental Engineering degree with a minor in Soil Science and a certificate in Organic Agriculture Systems. After graduation, she hopes to pursue a graduate degree in Biological Systems Engineering, with a focus on the study of agriculture's impact on the environment. Her upbringing on a dairy farm with a confined animal feeding operation contributed to her interest in seeking solutions to mitigate agriculture's impact on the environment.

Grant G. Davids was honored for his 40 years of service to the irrigation and water resources management profession. As president and founder of Davids Engineering, he has dedicated his career to the understanding, promotion and advancement of sustainable water management practices. In his nomination, Bryan Thoreson wrote, "Grant's dedication to scientific principles, technical excellence and continued support to USCID is the hallmark of his career."

In a letter supporting the nomination, Steve Macaulay wrote, "He is widely recognized in the western United States as one of the top professionals in irrigation management, with a deep understanding of both the theory and practical application of on-farm and irrigation district management practices and the underlying science."

Davids grew up on a dairy farm in California's Sonoma County and earned a B.S. degree in Agricultural Engineering at California Polytechnic State University. Prior to founding Davids Engineering in 1993, he worked at JM Lord, and CH2M Hill. He also worked on a large, World Bank-funded project in Sri Lanka. He served two terms on the USCID Board of Directors, including four years as President.

W. Martin Roche, recipient of the USCID Merriam Improved Irrigation Award, is a consulting civil engineer in Grass Valley, California. His professional career has spanned more than 48 years, including 27 years with the Bureau of Reclamation and five years with the Turlock Irrigation District in both technical and management positions.¤

USCID 10th International Conference, Sacramento

Sam Schaefer, USCID Board Member, represents Corporate Member GEI Consultants.

Justin Harter (left), Naches-Selah Irrigation District, and Carl Pitzer, Thompson Pipe Group.

Todd Hargrave, MACE, an In-Situ Company.

Dinner Speaker Tage Flint, Weber Basin Water District, Layton, Utah.

Roy McClinton, HUESKER, Inc.

Jack Goldwasser (left), Watch Technologies, and Paul Peschel, Kings River Conservation District.

Fred Holloway, Stevens Water Monitoring Systems, Inc.

Stewart Sorensen, Aqua Systems 2000 Inc.

Ryan Blanchard (left) Willowstick Technologies, and Jae Hyouk Lee, YOOIL Rubberdam Engineering.

October 24-27, 2017

Peter Moller (left) and John Krukar Rubicon Water.

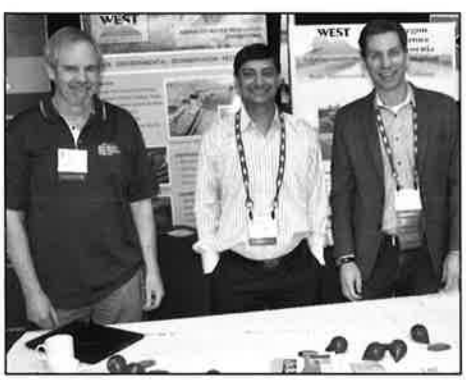
William Stammer and Peggy Graham, Advanced Drainage Systems, Inc.

Tony Sannella, Sage Designs, Inc.

Scott Davis, TruePoint Solutions.

Michael Sundham, SonTek.

Linh Nguyen (left) and Maaike Hough, George Cairo Engineering, Inc.



Bert Clemmens (left), Om Prakash and Brian Wahlin, WEST Consultants, Inc.

Becca Fong (left), KISTERS North America, Inc., and Pooneh Pahlevani, New Mexico State University.

Charles Burt and Sierra Layous, Irrigation Training & Research Center.

President's Message (continued)

falls far short of potential due to a lack of access and rights to water for irrigation, flexible financing, technology, linkages to markets, and the capacity to manage production. Irrigation in agriculture has tremendous potential to increase crop yields, support crop and livestock value chains, reduce poverty and improve health in these areas.

In the past, most World Bank projects have focused on large-scale projects. However, there is also a need to focus on small-scale projects (i.e., farmer-led irrigation) because the impacts can be as significant as the impacts of large-scale projects. Future policies should consider small-scale, farmer-led agriculture and there should be more support for rural infrastructure such as roads, rail and shipping.

Some of the concepts discussed in the International Forum included the potential of solar power for pumping irrigation water, the need for improving conveyance systems, and the importance of developing programs to involve young people. In addition, collaboration between the public and private sectors is crucial in order to develop sustainable small stakeholder farms. Inadequate public sector investment and coordination is a major obstacle for agriculture in Africa. As a result, many small stakeholder farmers do not have access to the necessary resources. In the past, the private sector has avoided investing in agriculture in Africa because of the perceived risks involved. Removing the obstacles to the risks is key.

Traditionally, Africa has been behind with regards to technology in irrigation. However, that actually puts Africa in an advantageous position moving forward, as they can now implement new high-tech systems more efficiently because it is more efficient to install new implementations from scratch rather than to rehabilitate already existing systems. Some of these new technologies include rain water harvesting, pumps and tube wells, drip irrigation systems, control sensors, smart phone apps, and solar power pumps. It is important that these new technologies be applied in the proper place and for the proper use.

USCID Member Michael Davidson speaks during the World Bank forum.

Center pivots are typically thought of for use only in large-scale productions as center pivots cannot serve smallholder farmers. However, a new concept is out there called the shared pivot concept. This concept allows multiple smaller holder farmers to share the same center pivot. Research is ongoing regarding the technology, financing, market linkage, and institutional support and mentoring that would be needed to make these shared center pivots a reality.

Many smallholder farmers in Africa rely on drilled shallow wells for water. Thus, there is a need to train farmers in the operation and maintenance of these pumps. In addition, solar pumping is relatively cheap and could make water more accessible by providing a way to pump more of Africa's groundwater resources.

Many of the smallholder farmers in Africa are women. Thus, there is a strong need for specialized skill development for both women and the youth in Africa in order to support smallholder farmers.

In the past, drought has been treated as a crisis, meaning that it is a one-time event and once it has passed, there is no need to worry about drought. However, drought should not be treated as a crisis but instead should be treated as a risk. There should be proactive (not reactive) steps taken that mitigate the risk of drought in the future. Thus, there is a definite need for a long-term strategy or policy to mitigate the risk of drought. Unfortunately, only a handful of countries have a drought risk mitigation policy. In some countries, drought early warning systems have been developed to detect when a drought is approaching so that proactive steps can be taken to help reduce the impact of the droughts.

So how do we move forward with the smallholder farmers? Knowledge is the way forward. That knowledge includes understanding the resource base (i.e., a water budget of the watershed). That knowledge also includes understanding what is happening on the small farms. In addition, small farms need to be part of the solution. Research and development is needed to formulate policy as well as develop new technologies for small farms. Farmers also need more knowledge, so training programs are essential as well as an institutional support system. Providing these services will help increase resiliency for the smallholder farmer.

Through technology and policy, it is important to lower the risk of entry for smallholder farmers. The private sector is key for the smallholder farmer.

Sustainability is an important concept and there are now new tools available to assess watersheds to help with this concern. There is a concern regarding groundwater pumping and making it sustainable. However, groundwater resources are more abundant in Africa that previously thought. These additional groundwater resources increase the appeal of solar pumping. A practice that can save water is alternative crop selection (e.g., move away from rice to a crop that requires less water). Also, the process of rice intensification reduces water use for growing rice.

It is important to stop silo thinking and to start thinking laterally. For example, look at the possibility of multi-use systems (e.g., crop production and growing fish in the canals). Soil management guidelines are needed. Improvements to infrastructure are needed such as better access to markets, internet, and canal modernization. However, high-tech does not always mean water savings. The technology must be applied appropriately to be effective. Alternative sources of water, such as reclaimed water, can help secure water resources for smallholder farmers.

Brian Wahlin
President, USCID¤

Strategies for Future Food Security

by Wayne Clyma, Water Management Consultant and Professor Emeritus, Colorado State University, Fort Collins, Colorado; and Dan L. Lattimore, Professor, University of Memphis, Memphis, Tennessee

Editor's note and Disclaimer: This article and the accompanying Editorial on page 22 are being published in this Newsletter to stimulate discussion and do not represent any USCID position or endorsement.

Introduction

Irrigated agriculture is a complex and often misunderstood enterprise. Food production requires farmers to manage this process dealing with multiple organizations that provide support. Many times the farmers' focus is merely to survive. Thus, food production in many parts of the world is a subsistence activity. To improve irrigated agriculture around the world involves assisting farmers to manage the process including working with the multiple organizations involved in this complicated, multidisciplinary enterprise.

Many years of involvement in irrigated agriculture suggest that successful irrigated agriculture involves critical elements and when one or more element is missing then production is reduced. For example, repeatedly farmers have access to excess water, but when timely delivery of the water is not assured, the farmer grows the crop as he would with a short water supply by reducing fertilizer and other inputs used. Thus, yields are greatly reduced. This process is repeated when seeds, fertilizer, credit or information is not available to the farmer-manager in a timely manner. Thus, an integrated approach to working with the farmer-manager seems essential.

Conference on Global Food Security

The conference on *Engineering and Technology Innovation for Global Food Security* indicated a continuing interest among agricultural professionals about how to address food and water scarcity in the future. The conference content seemed to suggest, though, that the focus was on a single emphasis to make necessary improvements. Single discipline efforts seem to be the common assumption about how food security can be addressed. This narrow approach will not address the needs for food production nor an equally important scarcity of water for increasing food production. The senior author has spent the past 40 years developing an interdisciplinary and inter-organizational approach to improving irrigated agriculture on five continents. This evolving process can improve irrigated agriculture through increased food production and reduce the scarcity of water. This management process brings together an expert team, a host country professional team, and public and private organizations with the farmers to accomplish significant increases in food production.

Food Production

Food and water scarcity are present issues and a growing potential catastrophe for the future. Water use is ineffective in many irrigation projects on most continents as currently being used and is expected to become increasingly severe. However, studies have shown water can be managed to make the supply adequate and even provide excess water. Food production in some areas of the world is serious enough for people to be starving or underfed. This condition will become more serious in the future with potential disastrous results.

One of the most serious problems existing in irrigated agriculture is that approaching 50 percent of the irrigated land is waterlogged and saline. This means half of the 275 million hectares of irrigated land is unproductive or very limited in its production. This may increase as new areas are brought into production. Good water management can largely reduce waterlogging and salinity and recover this unproductive land. This could add up to 50 percent more productive land for increased food production without building additional irrigation projects while saving water. The cost of recovering this land is much less than building additional irrigation projects.

The complex organizational management and technical (water management and food production) issues make accomplishing change in irrigated agriculture a difficult process. The personal and organizational conflicts that exist make the solution of management and technical issues in food production and water difficult to define and successfully solve. The status of future scarcity in food production and water makes these urgent issues to address successfully. Optimum food production and water management practices are often not known or used by irrigation professionals and farmers.

Waterlogging is evidence of wasted water. The waterlogging usually causes salinity and assures that these areas are unproductive or greatly limited in production. Additional land receives inadequate water because of the wasted water or is taken out of production. Farmers observed in repeated field studies do not plan or practice good crop production when the water supply is short or undependable. All these conditions combine to limit effective food production in irrigated agriculture.

Farm productivity is limited in irrigated areas because farmers do not follow known productive practices. Good seeds, fertilizer, pesticides, and weed control are known but usually are not available or effectively used. Credit and other support services are often not effectively coordinated with the farmers. Effective food production practices, poor water management practices, and inadequate water supplies limit productivity at the farm level to a fraction of the potential yield. Often, an area is just not farmed. Support organizations and farmers are often in conflict with resulting inaction or little action for improvement. Effective farm practices, supplies, and coordination with support agencies are essential elements of productive irrigated agriculture. Creating effective change in traditional irrigated agriculture can be accomplished using modern management strategies for change (Jones and Clyma, 1988; Dedrick, et al., 2000; Clyma, 2002).

Considerable concern today exists over the impact of climate change on food production. Many studies have shown that farmers worldwide produce food at less than the optimum or at consistently a subsistence level. In irrigated agriculture the major impact of climate change is reduced rainfall and greater shortages of water for irrigation. Assessments repeatedly have shown there is a greater supply of water available for irrigation than is necessary. Improving water management and effectively providing the more optimum water supply needed will provide sufficient water in many areas for optimum food production. Improvements in management also will greatly enhance food production. This is because the current level of production in irrigated agriculture is much lower than the potential level.

Where rainfed crops are grown, the rainfall may become insufficient or undependable enough that crop production cannot succeed. Since rainfed crop production has the same opportunities to improve food production through more effective management, the opportunities exist for increasing food production in rainfed agriculture by assessing needs and getting farmers and support units to effectively work together to achieve optimum food production.

The persistent approach of single discipline strategies to defining and solving the key constraints in food production and water makes success a consistent failure. The approach using interdisciplinary teams and collaborating organizations is a successful approach that is available.

Water Scarcity

Water is controlled into many canals using the upstream water level at a structure. Since water does not flow through critical depth in the structure, this is not a flow measurement. Many canals and their branches thus have water allocated without realistic flow measurement. The resulting flows on many locations in many different irrigation projects and countries are several times the target flow for that diversion. Many engineers have measured the flow under these conditions, and they are greatly surprised at the actual flow rate. Thus, farmers take more water from the canal below the branch and as a result more water flows to the branch canal. This causes the upstream branches to get more water because farmers are using more water. Variable supply rates also result when farmers use more or less water. Field conditions often result in the branch canals receiving three or more times the target flow rate.

Some structures for taking water from the branch canal to the watercourse that supplies farmers are designed to give the watercourse command a target flow rate. Often those structures are sabotaged by farmers or modified with unethical collaborations between the farmers and irrigation officials. These higher flow rates contribute to waterlogging and create deficits at the tail of the system or other areas within the command. A common farmer criterion is to apply water until it reaches the end of the field or covers high areas. Amounts of water applied to fields appear to be a random variable that commonly greatly exceeds water needs.

Water measurement is a missing technology in irrigation. Many engineers fail to understand this and believe that the excess water returns to the river with limited loss of water and little increase in salinity. Just the opposite is the case with much of the irrigated area lost from production because of waterlogging and salinity. The area lost continues to increase. This loss of irrigated area often is the most productive area of a canal command. Additional areas of the command have undependable, and usually inadequate water supplies. This shortage greatly reduces yields in much of the remaining irrigation command area not affected by waterlogging and salinity. Professionals commonly believe these improper distributions of irrigation water are not harmful and the wasted water cannot be saved by better management. These conditions result in irrigated crop production that only approaches twice rainfed production. Individual field yields of well-managed irrigated crops often are three to five times or more the rainfed yield. Irrigation often allows multiple crops per year also. This does not account for the potential for increases in yield in command areas where as much as 50 percent of the irrigated area is waterlogged and saline, or where water supplies are short because of the ineffective distributions. Also, the additional area that could be irrigated with the water saved through good management has not been counted.

Water management at the field level is mostly non existent. Studies in many countries including the United States show that field irrigation efficiencies are often in the 20 to 25 percent range (Clyma, 2002). Fields are not level and coupled with other poor production practices often yield only a fraction of their potential in many countries. Farmers often apply water to the field by observing when it reaches the end of the field or when the high spots are covered. Farmers can apply a measured amount of water if they are using a design developed for leveled fields. Then they can use their usual criteria of observing advancing water down the field (Wattenburger and Clyma, 1989). This criterion is commonly used in most countries including the United States. Thus, assuming level fields when most are not causes inefficient water distribution.

A diagnostic process that provides information for farmers and their supporting organizations can provide the coordination needed to help farmers achieve the potential yields for irrigated agriculture (Clyma, 2002). Water can be saved and yields increased many fold through an effective program.

Development Model for Improving Irrigated Agriculture

Forty years ago interdisciplinary expert teams were created to work with interdisciplinary host country teams to understand the priority needs for improving irrigated agriculture in a selected project. Expertise in organizational development and management were used to guide, facilitate and participate in the activities. An interdisciplinary field study was done to understand the needs of irrigated agriculture. This study defined how these needs could be met including the process to get irrigation officials and farmers to plan and carry out an implementation program that accomplished the new management defined.

Management Facilitation

Combining and integrating the understanding of expert teams and host country teams often involve important differences in information, observations, and technical knowledge. The management experts facilitate directed discussion, clarification, and understanding among the disciplines and the professionals from different experiences. Often important conclusions are reached that combine interdisciplinary perspectives with key technical knowledge and cultural factors important to the host country conditions. These efforts evolve from discussion and direction from the team leadership. These same strategies provide similar facilitation among farmers, irrigation professionals and organizational managers when defined interventions were planned. Another area where organizational development plays a key role is to create understanding within an organization about the needs and the plans to meet those needs. Communication with farmers for understanding, support and participation is essential. All participants are important to the management changes that need to occur. The key is for farmers to become effective managers of increased production with adequate support. The coordination among farmers and support units should become the norm instead of creating conflict.

Field Studies for Change

An intensive field study of an irrigation command provides an understanding of needs for improved irrigated agriculture that are not being met, as well as actions currently in place that need continued support or improvement. Actions to accomplish changes to make improvements in the support units and technologies provided to farmers initially were informal field demonstrations with the involvement of farmer leaders. The addition of the organizational development strategy to the process for change provides more effective, rapid changes and formally creates new units and relationships to carry out the improvement programs. Personnel involved with the change and observers of the effort repeatedly comment on the effectiveness and magnitudes of impacts the changes create. Some difficulties often are encountered, but by working with the farmers and creating changes where the relationships go through the program managers to the policy levels of the organizations, major changes can be accomplished (Jones and Clyma, 1988; Dedrick et al, 2000).

An example of one field study in the United Sates was on a recently rehabilitated irrigation project. Leaders in the rehabilitation project suggested there wasn't any need for improvement. Instead, the field study indicated improvements were needed for water delivery, water measurement, and communication among organizations and the farmers. The value of the changes was recognized within and outside the project (Dedrick et al, 2000).

The model to create the sustainable irrigated agricultural system is shown in . . The model evolved over nearly 25 years and experiences in several countries (Lowdermilk et al, 1983; Clyma and Lowdermilk, 1988; Jones and Clyma, 1988; Dedrick, et al, 2000). The initial phase is diagnostic analysis for understanding the management of the system (Clyma and Lowdermilk, 1988). The second phase is the management planning to create the coordination and collaboration among operational units and farmers to carry out the improvements and changes necessary for improving performance (Jones and Clyma, 1988; Levine, 1989). Management facilitators also supported planning the program, improving the understanding between professionals, and between professionals and farmers of how irrigated agriculture performs. Then the agencies and farmers plan and carry out the performance improvements (final phase). Continuing coordination and collaboration are important activities in this phase as technologies are introduced, personnel are trained, improvements are made by farmers supported by involved irrigation professionals and organizations. (Jones and Clyma, 1988; Dedrick, et al., 2000).

Figure 1.

Diagnostic analysis is viewed by some as an activity done once in a distributary command that is appropriate for the whole irrigated area. While an infinite number of studies are not necessary, new command areas will need a study or at least a rapid assessment. These studies create the understanding necessary to make improvements. Professionals and farmers working together need to understand and address the priority issues in the command area. Experience should be the basis on which field studies are reduced in scope or time. Some activities to establish understanding with the farmers may have to be created.

Changing organizations is viewed by many professionals as a long-term effort. Experience using the development model suggests that changes can be accomplished in a short time frame of a few months because the changes are created from a knowledge of field conditions, and approved and initiated from the policy level. Mid-level professionals are involved in the discussions of change. They also are involved in the decision-making so that they support the change. Policy level and mid-level professionals support the organization to accept and make the changes at the operational managers' level. Operational level managers and professionals successfully carry out the changes with farmers because they were involved in understanding the needs.

Impacts of the changes can be rapid and significant. Yields can be increased during a season with instant support from the farmers. Water demand can be reduced by improving the efficiency and effectiveness of the irrigation. Waterlogged and saline areas start to decrease as farmers see increased available farm land. Increased water supplies from water saved can allow increased farming area either on the farm or in areas of the command that are short of water such as at the tail of a watercourse or supply canal. Many irrigation professionals have suggested that a country can make a more significant impact on productivity by improving water management than can be achieved by increasing irrigated area through building more dams. After all, waterlogging and salinity consumes nearly 50 percent of the irrigated area worldwide. Recovering that area by creating sustainable irrigation systems makes available additional productive irrigated area. The cost of recovering the area is likely less than building a new irrigation project and the improvement results likely can be achieved more rapidly.

Creating change produces impact. Assessments must determine the magnitude and value of these impacts. Adjustments may have to be initiated to support more effective changes. As experience is gained in an area, new improvements may be identified and the organizations and farmers may need to adjust the improvement program. Because key needs will be understood, actions to resolve excessive water applications, inadequate support of farmers, or recovering waterlogged and saline land can be rapidly initiated. Making these changes will increase the sustainability of irrigated agriculture in the area. Such an approach is the key strategy for attaining sustainable irrigated agriculture and improving food production.

Conclusions and Recommendations

The severity of inadequate food production worldwide can be mitigated through improved farming practices and modern water management in the world's vast irrigated farmland. However, the common practice of looking at increased efficiency of irrigation through only a single disciplinary approach has proven to be unsatisfactory with limited effectiveness. Farmers are ultimate interdisciplinary managers. To solve the need to increase food production, an interdisciplinary team approach is needed to work with the farmers and local irrigation organizations.

Continued improvements can be initiated as new understanding of needs develop and trust increases among participants. Both professionally identified needs and farmer identified needs from a combined perspective can be addressed. A proven process of using interdisciplinary teams working with farmers to understand and define the management issues of their irrigation projects is needed. Through this process farmers work with professional experts to understand their needs and to develop plans to overcome identified problems through changes by both the local organizations and farmers in the area. Those needed changes must be implemented to improve irrigated agriculture and to ensure success in achieving increased food production.

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Evapotranspiration Manual Available

During 2016, ASCE published Manual of Practice 70 — *Evaporation, Evapotranspiration, and Irrigation Water Requirements: Second Edition.* The Manual was edited by USCID Members **Rick Allen** and **Marvin Jensen**.

The 2016 USCID Conference in Fort Collins addressed evapotranspiration issues. USCID purchased 150 copies of the MOP at a substantial discount and gave a copy to each Conference registrant.

A few copies of the MOP are available for USCID Members at our cost. Send an e-mail to info@uscid.org for purchase details.¤

Editorial: Food and Water Security

by Wayne Clyma, Water Management Consultant and Professor Emeritus, Colorado State University, Fort Collins, Colorado; and Dan L. Lattimore, Professor, University of Memphis, Memphis, Tennessee

Food demand is expected to double by 2050 according to the United Nations Population Division that projects the world population will reach 9.1 billion by that year. Of the 570 million farms in the world, 500 million are small, family farms. With more than 80 percent of world food production coming from these small, family farms, it is unlikely that increased food demand will be addressed by increased productivity without large scale local initiatives (FAO, Innovation in Family Farming, 2014).

At the 2014 Global Engagement Day sponsored by the American Society of Agricultural and Biological Engineers, the editors concluded that translating and adapting technical knowledge to local applications is a significant challenge and must consider local and regional resources, both physical and human as well as cultural acceptability." (ASABE, Spring 2015).

Finding local solutions and implementing them is not easily accomplished. However, one local approach that has done that in several localities throughout the world with small, family farms in irrigated agricultural areas has proven successful.

One strategy to impact these conditions has been to do interdisciplinary field studies with combined expert and host country teams working with farmers and supporting units to understand how the system works. These local water command area studies, called diagnostic analysis, have found that one of the primary causes for low levels of food production is the conflict that keeps farmers and organizations from working together. Another major issue is getting support organizations to provide the resources so farmers can produce food more effectively. Government or local policies may also be a major obstacle to increased productivity. These farmers and organizations have internal conflicts and external conflicts with each other that prevent effective changes and accomplishment of goals.

Organizational and management processes change people and organizations as a part of the process. Resolving these issues along with overcoming the technical water management issues provide the basis for substantial productivity increases using much less water. Good water management can resolve water logging and salinity that constraints productivity on nearly half the world's irrigated area. This could even double the productive irrigated area and provide sustainable irrigated agriculture. One of the primary water management concerns that these studies often identify is inadequate water measurement and distribution causing some fields to be over irrigated and some to have inadequate water supply. As a result the subsistence farmer will hesitate to plant crops when he is unsure of the reliability of the irrigation system.

Three major values to this local approach are:

1) to get an accurate examination of the real, not perceived problems,
2) to determine workable solutions to those problems, and
3) to involve all the stakeholders in the needs and efforts to improve the local agricultural system.

As farmers, local agricultural experts, policy makers and outside professionals work together through a field study they all become vested in a positive outcome. These interdisciplinary team field studies identify where improvements in the agricultural system can be made and then develop plans to overcome those constraints. While these needed changes often include technical refinements such as land leveling, they may also include changes in policies that will support necessary improvements by the small, family farmer that will increase productivity. The whole process creates understanding and often results in policy mandates to consider change. The diagnostic analysis data defines the needs for change and from field level to policy level change is more readily understood and accepted.

This approach that we label "diagnostic analysis" and includes changing organizations and people is a process that can be implemented at the local level with all the supporting units to improve the small family farm productivity and increase their yields dramatically. Farm income also would increase greatly. This could have a large worldwide impact on food production if donors, country officials, and agricultural leaders commit to such a strategy to improve irrigated agriculture. It will take that magnitude of effort to meet the food demands of the future.¤

USCID Newsletter Advertisers, Winter 2018

News of Members

Albert J. Clemmens, WEST Consultants, Inc., received the 2017 American Academy of Water Resources Engineers Service Award. He was recognized for his outstanding contributions to the Academy.

Kristoph-Dietrich Kinzli is now a Teaching Professor in the Department of Civil and Environmental Engineering, Colorado School of Mines, Golden, Colorado.¤

WEST Consultants Marks 30 Years

March 17, 201, marked the 30th year anniversary for WEST Consultants, Inc., a firm dedicated to providing specialized water resources engineering services relevant to **W**ater, **E**nvironment, **S**edimentation, and **T**echnology. WEST was incorporated in 1988 by Jeffrey B. Bradley, in San Diego, California. WEST has grown to include nearly 50 staffers distributed among seven offices located in four states. WEST personnel are recognized as computer modeling experts in hydrology, hydraulics, geomorphology, sediment transport, and water quality.¤

Norman Evans, 1922-2018

Norman Allen Evans, PhD, 95, died January 25, 2018, at his home in Fort Collins, Colorado. Dr. Evans' distinguished career in agricultural engineering spanned more than 40 years. He retired as professor emeritus, Department of Civil and Environmental Engineering at Colorado State University. He was a director of the Colorado Water Research Institute, and member of the first Colorado Water Quality Control Commission. He also served on the Fort Collins Water Board and the Poudre Landmarks Foundation.¤

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USCID Notes

by Larry D. Stephens, Executive Vice President

Congratulations to USCID President **Brian Wahlin** for his election to the position Vice President of ICID. He was elected during the ICID meeting in Mexico City last fall and will serve a three-year term.

You may have noticed that USCID's mailing address has changed. Wright Water Engineers is now hosting USCID. Sincere thanks to **Ken Wright**, WWE Founder and President Ian Paton for inviting us to relocate. The move from lower downtown Denver was required, as the 30-year cooperation between USCID and the U.S. Society on Dams ended in December 2017.

I hope to see many of you in Saskatoon, Canada, next August for the ICID annual meeting and an International Conference. As mentioned in the past, serving on an ICID work body is an excellent opportunity to become involved with irrigation and drainage activities from a global perspective. The networking is rewarding. And, you will find that many of the issues facing irrigation professionals in the U.S. are also being experienced elsewhere, while some issues are more localized.

As noted on page 24, Norman Evans recently passed away. Norm was head of the Colorado State University Agricultural Engineering Department and my advisor while I pursued my B.S. in Ag Engineering. Several ag engineers in the Fort Collins area meet for lunch once a month. The lunches are organized by **Tom Trout** and a number of colleagues and friends attend, including **Marvin Jensen** and **Stephen Smith**. So, I got to see Norm a few times during the last year.

Sadly, another member of the ICID family recently passed. Prof. Brane Maticic from Slovenia served as a Vice President of ICID during the 1990s. Brane was a friend and a strong supporter of ICID.

If you are involved with evapotranspration, don't miss the story on page 21. A few copies of the *ASCE Manual of Practice on Evapotranspiration* are available to USCID Members at a substantial discount. "First come first served!"

Please make plans to attend the next USCID Conference, in Phoenix during mid-October. Conference Co-Chairmen are **Brian Wahlin**, WEST Consultants, Inc., and **Eduardo Bautista**, ARS, USDA. The Water Research Foundation is a Cooperating Organization. The Foundation has been quite involved with water reuse, so is a great fit as we address the Conference Theme, *Water Reuse and Non-Traditional Water Sources for Irrigated Agriculture*. The Foundation is an internationally recognized leader in water research that is dedicated to advancing the science of water by sponsoring cutting-edge research and promoting collaboration. Additional information about the Foundation at their website www.waterrf.org.

Watch the USCID website soon for the Phoenix Conference preliminary program, and by early summer registraion, exhibition and sponsorship information. Hoping to see many of you at the Conference next October!¤

USCID Meetings

October 16-19, 2017, Phoenix, Arizona, 11th International Conference on Irrigation and Drainage. Theme: *Water Reuse and Non-Traditional Water Sources for Irrigated Agriculture.*

ICID Meetings

May 2-4, 2018, 8th Asian Regional Conference, Kathmandu, Nepal.

August 12-17, 2018, 69th IEC and International Conference, Saskatoon, Canada.

January 16-18, 2019, 9th International Micro Irrigation Conference, Aurangabad, India.

September 1-7, 2019, 70th IEC and 3rd World Irrigation Forum, Bali, Indonesia.

September 22-28, 2020, 71st IEC and 24th Congress, Sydney, Australia.