Independent Panel on Appropriate Measurement of Agricultural Water Use

Convened by the California Bay-Delta Authority

FINAL REPORT

SEPTEMBER, 2003

September 2003

Mr. Tom Gohring
Assistant Deputy Director, Water Management
California Bay-Delta Authority

Dear Mr. Gohring:

Attached please find our Final Report on the Definition of Appropriate Agricultural Water Use Measurement. We believe appropriate measurement is essential for the well being of California and its natural resources.

The Report, representing the consensus view of all six panelists, puts forward the Panel's definition of appropriate agricultural water use measurement. The Report represents more than two years of work.

As readers will see, a definition of appropriate agricultural water use measurement defies a simplistic answer. Nonetheless, the Panel believes it is putting forward a perspective that is grounded in a thorough analysis, is meaningful given today's agricultural water use measurement practices and needs in California, and is useful for future deliberations by affected stakeholder communities and state decision-makers.

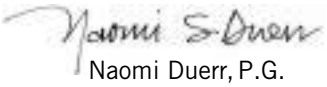
The recommended definition of appropriate agricultural water use measurement builds upon the extensive technical analysis conducted by Authority staff and consultants. The Panel believes the analysis is both consistent with past Panel guidance and sufficient to support the Panel's deliberations.

The recommendation also is shaped by the important and ongoing involvement of stakeholder and agency representatives. These representatives, many participating in an unpaid capacity, provided essential information on local conditions and perspectives throughout the process. The Panel wishes to thank these many individuals for their remarkable commitment to this effort.

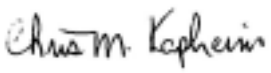
Finally, while the Panel recognizes that concepts included in this report may be controversial to some, the Panel believes it has honored its commitment to—in a neutral manner—put forward a consensus definition rooted in well-informed and well-reasoned deliberations.

The Panel hopes this Report will be useful to the stakeholder and agency representatives who must now craft a strategy for implementing this consensus definition. We are available to answer questions or concerns that may arise as this process moves forward.

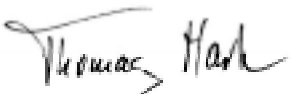
We thank the Authority for the opportunity to be involved in this effort and compliment it on its efforts to further California's understanding of this important topic.



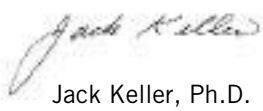
Naomi Duerr, P.G.
South Florida Water Management District



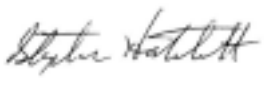
Chris Kapheim
Alta Irrigation District



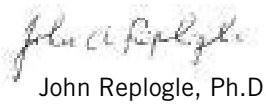
Thomas Harter, Ph.D.
University of California, Davis



Jack Keller, Ph.D.
Keller-Bliesner Engineering, LLC



Steve Hatchett, Ph.D.
Western Resource Economics



John Replogle, Ph.D.
U.S. Water Conservation Laboratory

TABLE OF CONTENTS

EXECUTIVE SUMMARY

BACKGROUND

The August 2000 CALFED Record of Decision (ROD) called for legislation requiring the appropriate measurement of all water uses in California. As a first step towards that goal, the ROD directed that a panel of independent experts be convened to help define appropriate agricultural water use measurement.

APPROACH

Based on this and related ROD commitments, the California Bay-Delta Authority (Authority)—formerly referred to as the CALFED Bay-Delta Program—convened six nationally recognized experts who collectively provided understanding in the areas of measurement technology/hardware; resource economics; groundwater hydrology; technical water policy; water district operations; and, irrigation engineering.

The Panel, first convened in June 2001, deliberated over a two-year period. The Panel's deliberations were informed throughout by the ongoing involvement of stakeholder and agency representatives with both policy and technical perspectives. Additionally, the Panel's deliberations were grounded in an extensive technical analysis shaped by the panelists and conducted by Authority staff and consultants.

FINDINGS

The attached Panel Report, representing the consensus view of all six panelists, puts forward the Panel's definition of appropriate agricultural water use measurement.

Building off the regionally based technical analysis, the Panel's recommended definition focuses on those measurement practices panelists identified as likely to—in a cost-effective manner—support state and federal planning and water rights objectives, allow water users to undertake and demonstrate the effects of efficiency measures, and facilitate valid water transfers. Key elements of the Panel's definition include:

Farm-Gate Measurement: Require districts to report delivery data to the State. State and federal planners are currently unable to adequately assess the potential of on-farm water use efficiency improvements due to gaps in how farm-gate delivery data is presently collected and reported to the State. Accordingly, the Panel recommends that districts be required to report aggregated farm-gate delivery data to the State. Changes in methodology are not recommended at this time, since current practices—whether estimated or directly measured—are considered sufficient to support both water transfers and efficient on-farm water management practices. Moreover, roughly 90% of all farm-gate deliveries are already measured at an accuracy of ± 6% by volume. This recommendation is not intended to preclude state and federal entities from linking approval of site- or condition-specific grant-funding applications or water contracts to higher levels of farm-gate measurement.

Groundwater Use Measurement: Employ more precise methods to compute and report net usage to the State. Current state and federal characterizations of groundwater resources are not conducted using consistent methods and are not done frequently enough to adequately characterize groundwater usage. This hampers the State's efforts to determine the amount of groundwater used in various regions and to characterize the extent of overdraft. Accordingly, the Panel recommends that the State employ more precise methods—specifically, continuous regional characterization of groundwater—to compute net usage. This approach, expected to cost the State an additional $2 million per year, represents a substantial change from current practices. This recom-

mendation is not intended to preclude the most precise measurement standards, which are needed to support water transfers or are required by various authorities to meet site- or condition-specific needs.

Crop Water Consumption Measurement: Measure using satellite-generated remote-sensing. Current approaches to measuring crop water consumption rely on indirect methods applied infrequently, a practice that means state estimates of crop consumption—a significant portion of California's total water use—are not validated and could include significant error. The Panel's recommended approach—using satellite-generated remote sensing to measure crop consumption—is expected to yield significantly better estimates than current practices. It represents a minimum of $500,000 additional annual cost to state or federal water agencies, and would have no direct impact on water users.

Surface Water Diversion Measurement: Measure all major surface water diversions using the best available technologies and report data to the State. Accurate data on surface water diversions is essential if state and federal water agencies are to adequately manage and plan for current and future needs. The completeness, consistency and accuracy of current reports do not allow these managers to quantify the amount of water diverted. Accordingly, the Panel recommends that all major surface diversions employ the best-available technologies—such as flow-totaling devices and data loggers—and report the data to the State. As most diversions are already using best-available technologies, the impact to districts is expected to be minimal.

Undertake comprehensive reviews to determine measurement needs for return flows, water quality and in-stream flows. The Panel recognizes that measurement of return flows, water quality and in-stream flows is

Agricultural vs. Urban Water Use: Measuring Water Delivery to End Users

PREPARED BY PANELIST JACK KELLER, ON BEHALF OF THE PANEL

Different approaches are required to measure water deliveries to agricultural and urban water users because of inherent differences in agricultural and urban demand patterns, delivery systems, water quality, and costs (see Table Below).

Perhaps the most fundamental difference between agricultural and urban water systems is their patterns of use which dictate important characteristics of their delivery systems. Urban water is available to all customers on demand—although the range of flow is typically low, when an urban water user turns on the tap, water comes out. This level of service is expected by residential and industrial customers throughout the United States. To provide this level of service, urban water systems—storage, pumps, and pipes - must be sized to provide peak water demand to many customers at once while meeting fire hydrant flow and pressure standards. Because urban water users can take water many times a day at different flow rates, only a recording measurement device—such as a totalizing meter—can give accurate delivery data.

On the other hand, agricultural distribution systems are sized to deliver water to only a few customers at a time on delivery schedules that provide water to farms once every two to six weeks. Typical agricultural delivery systems are designed to provide water for traditional surface irrigation methods that periodically apply relatively large quantities of water to a field and then use the on-farm water storage properties of the soil root zone to provide water to the crops between irrigations. These systems must use either fixed rotational or arranged delivery schedules to match deliveries to system inflow. Over-delivery results in some customers not getting their optimal flow rate; under-delivery results in canal spills (most agricultural water suppliers use open-channel gravity-flow delivery systems). Either of these conditions leads to low water use efficiency. Water district operators usually measure water delivery flows during these delivery events to make sure that their canal system does not get out of balance. As a result of these operational requirements, agricultural water suppliers typically have a record of the farm delivery flow rate and duration for each water use event. This data can be used to estimate the volume of water delivered even without a recording water measurement device.

Agricultural water quality and the variability of agricultural deliveries also affect end user water measurement. Farm size, crops, and irrigation methods are different from field to field. Water delivery rates can even vary on a given field from one irrigation event to another because of plant maturity or cultural practices such as rice paddy flood-up. Flow rate changes are even possible during an irrigation event due to irrigation management actions. Unlike urban water systems that deliv-

needed to support a variety of state and federal water management objectives. However, given the lack of information regarding the location, distribution and type of existing measurement for these locations, the Panel was unable to develop a more specific recommendation at this time. The comprehensive reviews are recommended as a state follow-on responsibility.

Additionally, the Panel stressed that its definition is not static and is likely to defy a one-size-fits-all prescription. Any implementation approach must be adaptive, include appropriate exemptions, and allow for local flexibility and creativity.

NEXT STEPS

Following review of this material with the Authority's public advisory bodies, the Authority intends to move forward with its next step: developing an implementation strategy capable of being broadly supported by affected stakeholder communities. This phase, expected to take no more than six months, will incorporate the following tasks:

Program Manager Work Group: Convene a diverse stakeholder group to give guidance to Authority staff in developing an implementation proposal.

Public Reviews: The proposed approach will be discussed with CALFED advisory and decision-making bodies, and the public. (This step might also incorporate an urban water use measurement approach, which is being developed separately.)

Legislative/Agency Discussions: Finally, the Authority will work with state policymakers, as necessary, to put forward an implementation approach. This approach could necessitate legislative changes, administrative changes or both.

Though the issuance of this Report represents the Panel's final task, the Panel remains available to answer questions that may arise as this process moves forward.

er potable water, agricultural systems contain debris such as plant matter or algae. Consequently, agricultural water measurement devices must handle a variety of flow rates under very difficult conditions. For example, while a water meter may work adequately at the beginning of the irrigation season when flow rates are high and debris is low, later in the season they may not work at all because flow rates have been reduced below the operating range of the device or because aquatic weeds foul the impeller. Because agricultural delivery flow rates, system configurations, and water quality varies so much, agricultural water end user measurement defies a "one size fits all" solution.

Finally, the relative costs of measurement are very different in agricultural and urban settings. For residential customers, the cost of implementing measurement (hardware, meter-reading, etc.) represents an increase in water rates of $5 to $20 per month ($60 to $240 per year). On the other hand, agricultural farm-gate measurement represents an increase in farm costs for a single field of $30 to $200 per month. For most crops, this is a significant fraction of farm income—in some cases eliminating the ability of the farm to make a profit. This high sensitivity to the cost of end use water measurement makes decisions about farm-gate measurement particularly significant.

COMPARISON OF AGRICULTURAL & URBAN RESIDENTIAL WATER DELIVERY SYSTEMS

Characteristics	Agricultural	Urban Residential
Demand Patterns	Ability to serve peak crop ET and typical losses; only deliver to 5% to 15% of customers at a time	Ability to serve peak demand and meet fire hydrant flow/ pressure standards; could serve virtually all customers at once
System Hardware	Mostly open channel, gravity flow; unexpected changes in deliveries can result in canal spills	Piped and pressureized systems; pipes flow full
Delivery Frequency	Deliveries arranged in advance or on fixed schedule (rotation) - two to six weeks between deliveries	Deliveries available on demand
Delivery Rate	0.5 to 20 cfs (225 to 9,000 gpm)	0.5 gpm to 20 gpm
Delivery Duration	2 to 72 hours	5 minutes to 2 hours
Water Quality	Untreated, contains debris	Treated to potable standards
On-Site Storage	Root zone stores crop demand for 2 to 6 weeks	None

INTRODUCTION

OVERVIEW

Measurement of water usage in the agricultural landscape is nearly as varied as the crops themselves. Some regions or districts rely on precise and frequent measurement to track how water moves through and within their systems. Others depend more heavily on estimates. The current approach to measurement grows out of unique, place-specific histories, economics and needs.

Water users and suppliers rely on the information generated for a variety of purposes. Measurement data can help local water districts distribute water to users, make operational decisions and improvements, and charge for water according to the amount used.

More recently, as California's water resources have become increasingly scarce, diverse stakeholder groups also have recognized the importance of measurement to state and federal agencies trying to manage a much-in-demand resource. Measurement can, among other things, provide better information on statewide and regional water use to support planning and water rights objectives, allow water users to undertake and demonstrate the effects of efficiency measures, and facilitate valid water transfers.

IMPETUS FOR THE PANEL

The California Bay-Delta Authority (formerly referred to as the CALFED Bay-Delta Program) is a cooperative effort among state and federal agencies and the public to ensure a healthy ecosystem, reliable water supplies, good quality water, and stable levees in California's Bay-Delta system.

Recognizing the potential impact of water use measurement on these overarching goals and the intense stakeholder interest in this topic, the August 2000 Record of Decision (ROD) called on the Authority's Water Use Efficiency (WUE) Program to take a closer look at measurement and determine what is needed and, as appropriate, put forward legislative or other strategies to bolster the current approach:

> "Diverse stakeholder groups have recognized the importance of, and need for, appropriate measurement of water deliveries. Measurement will provide better information on statewide and regional water use, enable water purveyors to charge for water according to the amount used, allow water users to demonstrate the effects of efficiency measures, and facilitate a water transfers market. CALFED Agencies have initiated a public process to add greater definition to 'appropriate measurement':
>
> - An independent review panel on appropriate measurement will be convened. This panel will provide guidance that will help define appropriate measurement as it relates to surface and groundwater usage. The panel will prepare a consensus definition of appropriate measurement by the end of 2001.
>
> - At the completion of this stakeholder/technical process, CALFED Agencies will work with the California State Legislature to develop legislation for introduction and enactment in the 2003 legislative session requiring the appropriate measurement of all water uses in the State of California."

Based on this ROD commitment, the Authority convened an Independent Review Panel on Appropriate Agricultural Water Use Measurement to: (1) assist it in defining appropriate measurement as it relates to agricultural water use efficiency; and (2) outline possible steps for moving forward. [The

ROD-stipulated deadlines noted above have shifted to satisfy the Panel's subsequent call for a more detailed and time-consuming analysis than initially anticipated.]

The intent of the Panel's deliberations were neither to chart nor preclude any particular implementation path. That task is to be handled in subsequent stakeholder discussions and will, like other facets of the Authority's Water Use Efficiency Program, be underpinned by the Program's commitment to regionally sensitive, incentive-driven and cost-effective approaches. (A separate process is being used to address urban water use.)

PANEL PARTICIPANTS

In designing the Panel, the Authority sought to bring together a cross-disciplinary mix of independent experts capable of credibly tackling the potentially controversial question of defining appropriate agricultural water use measurement for both surface and ground water. The Authority further strove to craft a set of deliberations that would be objective-driven, involve the input of affected and informed stakeholder communities, be outcome-focused, and be perceived as credible.

To recruit panelists, the Authority worked with stakeholder and agency representatives to identify and select nationally recognized technical experts who collectively were able to provide understanding of the following areas:

Measurement technology/hardware: This panelist is to bring an understanding of existing and emerging measurement technologies and hardware. He/she should also be familiar with the technological limitations.

Resource economics: This panelist is to bring expertise related to the costs and benefits associated with measurement. He/she should also be familiar with issues related to financing measurement improvements.

Groundwater hydrology: This panelist is to bring an understanding of the purposes, benefits, limitations and costs associated with groundwater measurement.

The Value of Information

PREPARED BY PANELIST NAOMI DUERR, ON BEHALF OF THE PANEL

Water measurement plays an important role in managing California's water resources.

PLANNING AND MANAGEMENT

In order to manage California's water, the State must first know something about its characteristics, such as its quantity, quality, depth, location, ease of access, current use, and source and rate of replenishment. These characteristics must all be measured (or estimated). Once we have knowledge about a water system, we can assess how changes in weather, water withdrawal patterns, water uses, or restoration efforts might affect it. Measurement is key to understanding dynamic systems and assessing impacts to them over time.

BASELINE TO MEASURE EFFECTIVENESS OF CONSERVATION MEASURES

Water resources are increasingly valuable as demands rise over time. Conservation can be a cost-effective way to stretch water supplies. Conservation can delay the need to construct larger wellfields or to expand a community's water treatment facilities. Yet without measuring current water use, we can only guess at which conservation techniques might be most cost-effective. Should a farmer line a canal or invest in a drip irrigation system? Should a district build a new reservoir or store water underground? Only by measuring water use and understanding the nature of that use can we predict which conservation measures are likely to be most cost-effective. Once appropriate conservation tools are implemented, measurement is again key to quantifying actual gains and determining whether we are reaching our targets.

FINALLY, THE ACT OF MEASURING IMPLIES INTRINSIC VALUE

The accuracy with which we measure the use of a resource generally reflects its unit value—the cost of measuring more accurately needs to be justified by the benefit achieved. Resources which are perceived to have very high economic value per unit are measured precisely (diamonds are measured in hundredths of a carat), while resources with low unit value are measured imprecisely (fill dirt is measured to the nearest cubic yard). In the past, water supply for irrigation has been relatively abundant in some regions of California, due to firm and abundant water rights. Although water is extremely valuable to these areas (essential in fact), its marginal value has been relatively low. As a result, the cost of precise measurement has not seemed worth it. However, these days, good, clean plentiful water is not as available as it once was, and treatment costs have increased over time as concerns about purity have grown. If we appropriately measure water extraction, end use, return flows, and quality, we recognize water's inherent value. Valuing water is a cornerstone of sound resource management.

Ideally, he/she would have experience working in and out of adjudicated basins.

Technical water policy advisor: This panelist is to bring an in-depth understanding of how the integration and interpretation of large data sets can be used to inform public-sector policy making. This includes understanding: 1) what's required to collect and use data, and, 2) what are the relative costs and benefits of maintaining centralized data.

Water district operator: This panelist will contribute an on-the-ground perspective of a water district operator intimately familiar with agricultural irrigation in California.

Senior integrator/irrigation engineering: This panelist is to contribute expertise related to irrigation engineering. As well, this panelist will bring practical experience in recommending measurement programs for water agencies.

Potential panelists also were considered for their ability to meet the following criteria: 1) objectivity, as reflected in the perceived willingness/ability to integrate diverse viewpoints; 2) ability to work collaboratively; 3) understanding of the various objectives related to measurement; 4) practical experience with on-the-ground use of measurement; 5) competent and comfortable with analysis, storage, dissemination and use of measurement data; and, 6) availability. A list of the panelists, along with their expertise and affiliation, is provided in the chart below. (More detailed biographies are included in Appendix 1.)

To foster a process informed by local stakeholder views and perspectives, the Panel process also incorporated the continued input of diverse and informed stakeholders and state and federal agency representatives. These individuals participated in two different ways.

Technical Advisors: Each major stakeholder group—agricultural, environmental and agency—was asked to name three technical representatives to support the Panel's deliberations by helping the panelists and the Authority to better understand local issues and information sources. These Technical Advisors were invited to participate in Panel deliberations and provided interim guidance as well. A listing of these individuals is included in Appendix 1.

Ad Hoc Work Group: Each major stakeholder group—agricultural, environmental and agency—also was asked to name representatives able to provide more policy-focused guidance to the Authority and Panel. These participants—also invited to contribute to Panel deliberations and provide between-meeting guidance—served as a sounding board regarding Panel design, panelist selection and ongoing Panel process. A listing of these individuals is included in Appendix 1.

Finally, the Panel's deliberations were supported by a Technical Team consisting of Authority staff and consultants with expertise in hydrology, irrigation technologies and practices, resource economics, water law and stakeholder involvement/ facilitation. At times, panelists Jack Keller and Steve Hatchett also participated in a liaison role to ensure the Technical Team's work was consistent with previous Panel guidance. A listing of Technical Team members is included in Appendix 1.

PANELISTS WITH AFFILIATION AND AREA OF EXPERTISE

Panelist	Affiliation	Expertise
Naomi Smith Duerr	Director, Environmental Monitoring and Assessment Department, South Florida Water Management District	Technical Water Policy Advisor
Thomas Harter	Associate Cooperative Extension Specialist, Department of Land, Air and Water Resources, University of California, Davis	Groundwater Hydrology
Steve Hatchett	Economist, Western Resource Economics	Resource Economics
Chris Kapheim	General Manager, Alta Irrigation District	Water District Operator
Jack Keller	Professor Emeritus of Agricultural and Irrigation Engineering, Utah State; Founder and CEO, Keller-Bliesner Engineering	Irrigation Engineering
John Replogle	Research Hydraulic Engineer and Chief Scientist, U.S. Water Conservation Laboratory	Measurement Technology

PANEL MEETING SCHEDULE

Initially, the Authority anticipated the Panel process would require two meetings and last six to nine months. Given the complexity of the topic and early-on Panel guidance that directed the Technical Team to undertake an extensive, rigorous and region-specific analysis, the Panel's deliberations spanned two years and involved numerous in-person and teleconference meetings.

The Panel met in three face-to-face sessions. The first session, held in June 2001, focused on scoping questions and information needs related to the Panel's deliberations. The second session, held in October 2001, centered on an interim review of a preliminary technical analysis. The third and final session, held in June 2003, focused on developing a consensus definition of appropriate agricultural water use measurement.

The Panel also held numerous teleconferences to review the evolving technical analysis and provide continued input to the Technical Team. Panelists also reviewed and commented on interim staff technical analyses via e-mail.

Throughout the process, the deliberations were structured to incorporate and encourage the participation of affected stakeholder communities. As noted above, stakeholder and agency representatives were invited to participate in Panel deliberations. The public also was invited to attend Panel meetings. Finally, CALFED held a series of public workshops throughout the state to provide updates and information to interested members of the public.

TECHNICAL APPROACH

In its earliest deliberations, Panel members stepped out a series of topics essential to better understand prior to answering the primary question: What is the definition of appropriate measurement?

Most generally, the Panel called on the Technical Team to undertake a region-by-region analysis of the following:

- What are the purposes of agricultural water use measurement?
- What are the current baseline conditions, including an overview of measurement locations and intensities and regional snapshots?
- What are the benefits and limitations of the current approach?
- What would be the costs and benefits associated with altering the current measurement approach?

To develop comprehensive and credible answers to these questions, the Technical Team worked with the Panel and local consultants and stakeholders to undertake a rigorous analysis that relied on the following overarching methodology:

Implication of Irrigation Measurement Accuracy

PREPARED BY PANELIST JOHN REPLOGLE, ON BEHALF OF THE PANEL

Water measurement, as referred to in this document, is usually worded, for example, "…accurate to within ± 6% *by volume*." Water measuring devices may display either *flow rate* or *flow volume*, or both. Suppose a weir, which is basically a flow-rate device—that is, a depth reading used in an equation or table to indicate, say, 4000 gallons per minute—is fitted with a depth gauge on the canal sidewall that has been accurately referenced to the weir lip. However, waves make reading of the wall gage difficult to within 20% of the depth. The basic flume or weir may have a proven accuracy better than 2% to 5 %, but expensive stilling wells or sonic level detection and time-rate accumulation may not be practical at the site. Can this location produce a "*by volume*" measurement to meet accuracies to within ± 6% for system management and billing purposes?

The answer is that it is possible to meet the requirement. This is true because, if enough manual readings are accumulated over the delivery time of interest, some of the wave-hampered readings will be high and some will be low, so that by applying statistical methods, the sloppy readings (if enough are available) will give a volume delivery to the customer that approaches the basic 2% to 5 % accuracy of the weir. This would be well within the ± 6% target. The number of readings needed can be determined by statistics. However, the wide margin on individual readings does not bode well for the farmer who is trying to determine when to return to his canal gate to change the water to the next field. Ultimately, it is hoped that more precise instantaneous measurements can be implemented to improve the farmer's on-farm management. Meanwhile, for canal system operations, measurements of ± 15% by volume, is tolerated as being acceptable at individual customer levels, again because the random "overages" and "underages" of many customers will compensate and produce a volumetric accuracy suitable for the delivery authority who uses the information to assure that the main canal is adequately operated and for billing purposes.

The above explanation illustrates the desires of the Panel to incorporate and make use of flow measurements for one or more of at least two purposes. The limits recommended for a flow measurement that is accurate enough depends on the

Step One: Articulate objectives of measurement. The Panel called for the analysis to be structured to explore objectives of measurement (surface and groundwater) that support both specific Authority goals and broader statewide needs. In doing so, panelists strongly recommended that the analysis focus primarily on state and federal objectives related to water planning, water availability, water transfers and water use efficiency. At the same time, the Panel recommended that the analysis also identify important linkages between measurement and local objectives. The results of this analysis are presented in Section 1.

Step Two: Identify measurement components. In order to undertake a regional analysis, it was necessary for the Technical Team to develop a strategy for characterizing and considering changes to existing measurement practices. To accomplish this task, the Technical Team articulated three critical aspects of measurement: (1) the general location of where measurement is made (in other words, how the data is derived); (2) the intensity of the measurement; and, (3) the fate of the data associated with a measurement (how the data is used). The results of this analysis also are presented in Section 1.

Step Three: Track baseline conditions. In order to characterize the capabilities of existing measurement practices and estimate the incremental costs and benefits associated with different measurement strategies, it was first necessary to articulate the existing baseline conditions. This step necessitated working with regional experts to develop region-by-region estimates of existing measurement infrastructure and practices. It also required characterizing the State's current legislative and regulatory approach to measurement. These assessments are included in Section 2 (Baseline Conditions) and Appendix 2 (California Legal Authorities).

Step Four: Characterize benefits, limitations and potential changes to existing practices. Once baseline conditions were understood, the Technical Team undertook a regional analysis to: (1) characterize the ability of current measurement practices to meet the critical state and federal objectives identified in Step One; and, (2) identify possible and realistic changes to existing practices. In doing so, the analysis sought to identify—in a qualitative manner—the potential benefits to state and federal objectives if water suppliers and users altered their current measurement practices. The results of this analysis are presented in Section 3.

intended use of the measurement. One use of measurement information is for *flow volume* accounting over a day, a month or season. Water districts need information on volume of water delivered if they are going to equitably allocate water supplies to growers or bill growers by volume of water delivered. Growers need information on volume of water delivered if they are going to use a field water budget to schedule their irrigations. Here, as illustrated above, the measuring accuracy need not produce an instant reading that is highly precise at any moment. An example of "precise" is the ability to distinguish the markings on, say, a wall gage. "Accuracy" refers to the ability to determine a flow rate, or flow volume, in relation to some otherwise determined correct flow rate or flow volume. It is not always possible to have a correct value for comparison outside of a laboratory setting. On the other hand a "precise" reading may not necessarily equate to an "accurate" reading because the zero-setting on a weir may have shifted, or the rating equation or table may not be well matched to the structure, causing a bias error.

A more stringent and rarely needed form of measurement is for immediate *flow-rate* management applications. This situation could arise if that same farmer, mentioned above, needs to know instantaneously when he has applied the correct amount of water. For precision-leveled basin irrigation of upland crops at a steady, known flow rate, the irrigator can calculate a shutoff time. For example, irrigating 10 acres at 10 acre-inches per hour (10 cfs) will apply 4 inches in 4 hours. This measurement reading would need to be as precise and accurate as practical, because a 20% error in his single reading of the flow metering system could cause his shut-off time to be wrong by over three-quarters of an hour. However, this is less important for most other irrigation methods such as furrow and sloping border irrigation as the timing of irrigations is based on the relatively unpredictable time it takes for the water to reach the ends of the furrows or border strips. And for flooding rice basins, differences in flow rates merely alters the depth of the water stored in the basins.

For these reasons, the Panel believes the accuracy levels incorporated into its recommendations are both appropriate and achievable.

Step Five: Develop cost projections associated with different measurement practices. Relying on baseline conditions developed in Step Three and potential changes to measurement practices first outlined in Step Two and further considered in Step Four, the analysis looked at the quantitative costs associated with altering current measurement practices (both hardware and data management). These costs were developed at both regional and statewide levels. The results of this analysis are presented in Section 4.

Step Six: Analyze costs and benefits. As directed by the Panel, the last step in the analysis was to put forward a draft staff analysis of the potential quantitative costs and qualitative benefits associated with changes to current measurement practices and develop draft recommendations based on that analysis. This analysis also included any general recommendations related to future implementation considerations. The results of this regionally based analysis were presented to the Panel during its final set of deliberations and served as the foundation for their discussions. This analysis is included in Section 5.

The Technical Team relied on a variety of strategies and information sources to develop and confirm the analytic steps outlined above. It surveyed water suppliers and water users throughout the state, catalogued measurement practices and costs, talked with state and federal water managers and interviewed environmental stakeholders. Team members reviewed the State's regulatory and statutory framework, as well as talked with water managers in six other states to better understand their experiences. Additionally, the Technical Team met with local experts throughout the state to gather relevant data, present the results of its analysis and solicit feedback. Finally, public workshops were held to solicit feedback and comment on the analysis. (A summary of the public comment on the draft analysis is included in Appendix 4.)

More specific descriptions of the analytic techniques and information sources are outlined within each section of this report.

NEXT STEPS

As noted earlier, CALFED is committed to working through a two-step process to ensure it puts forward an approach to agricultural water use measurement that is both technically sound and capable of being broadly supported.

The first step—the Panel's determination of a definition of appropriate measurement—is summarized in this report, which will be distributed to and discussed with CALFED advisory- and decision-making bodies and the public. A summary of all public comments received on this Panel report will be attached as part of the permanent record.

Following these discussions, the Authority intends to move forward with the second step: developing an implementa-

Project Specific Costs and Benefits

PREPARED BY PANELIST STEVE HATCHETT, ON BEHALF OF THE PANEL

A comment received from water users concerned the need to evaluate the costs and benefits of measurement (especially farm-gate measurement) in the context of future water use efficiency and water management projects that might require or be enabled by better measurement. The comment suggested using a comprehensive benefit-cost evaluation of both the measurement approach itself and any linked future projects.

The Panel considered this comment seriously. The Panel's approach throughout the process has been that measurement needs to serve one or more defined objectives, and it has not recommended measurement levels simply because there may be future uses of the information. However, the Panel also felt that the Technical Team's ability to make reasonable and quantitative estimates of future benefits is limited. Therefore, the Panel came to two general conclusions regarding the comment:

1. It would not be reasonable to attempt to estimate the costs and benefits of future water use efficiency and management projects requiring or enabled by better measurement. Such an analysis would be virtually unlimited in scope and too speculative to be meaningful.

2. The state should be cautious in supporting measurement approaches that significantly increase costs when the benefits are uncertain. Rather, a tiered recommendation is preferred which sets a lower, but acceptable baseline level of measurement and then identifies conditions under which higher (more precise) measurement would be appropriate. These conditions could include: state grant funding of water use efficiency projects that require better measurement; and/or, local agency decisions to implement volumetric water pricing.

tion strategy capable of being broadly supported by the many affected stakeholder communities. This phase, expected to take no more than six months, will have several steps:

Program Manager Work Group: The WUE Program will convene a diverse stakeholder group to serve as a sounding board as it develops a proposed implementation approach. As discussed earlier, the Program's proposed approach will draw on the Panel's report and be shaped by the Program's commitment to regionally sensitive, incentive-driven and cost-effective approaches.

CALFED and Public Reviews: Once drafted, the WUE Program proposed approach will be drafted for review, discussion with and final revision by CALFED advisory- and decision-making bodies and the public. It is possible that this step will incorporate an approach to urban water use measurement that is being developed through a separate process.

Legislative/Agency Discussions: Finally, the WUE Program will work with state policymakers, as necessary, to put forward an implementation approach. It is uncertain at this point whether a final recommended implementation package will necessitate legislative change, administrative changes or both. Again, it is possible that this step will incorporate an approach to urban water use measurement that is being developed through a separate process.

Interested stakeholders are invited to review the accompanying materials and submit any comments to the California Bay-Delta Authority for its consideration as it continues discussions related to this important topic.

CVPIA Water Measurement Requirements

PREPARED BY USBR AGENCY REPRESENTATIVE TRACY SLAVIN, ON BEHALF OF THE PANEL

The United States Bureau of Reclamation requires all Central Valley Project water service or repayment contracts for agricultural, municipal, or industrial purposes that are entered into, renewed, or amended under any provision of Federal Reclamation law after enactment of the Central Valley Project Improvement Act (CVPIA), shall provide that the contracting district or agency:

- Ensure that all surface water delivery systems within its boundaries are equipped with water measuring devices or water measuring methods of comparable effectiveness acceptable to the Secretary within five years of the date of contract execution, amendment, or renewal;
- Ensure that any new surface water delivery systems installed within its boundaries or on or after the date of contract renewal, are so equipped; and
- Inform the Secretary and the State of California annually as to the monthly volume of surface water delivered within its boundaries.

This requirement is also incorporated into the Criteria for Evaluating Water Management (Conservation) Plans (Plans) prepared under the CVPIA. The Plan is required of each contractor which receives more that 2,000 irrigable acres or receives more that 2,000 acre feet in their service area, or receives more than 2,000 acre feet for M&I purposes. For these contractors, the Plan can be used to ensure that they are meeting the water measurement requirements under CVPIA.

The Water Conservation Criteria were first developed in 1993 through an extensive public scoping process. Water Measurement to each farmer was determined to be a Best Management Practice (BMP) that, when tied with volumetric pricing, provided farmers with a strong price signal resulting in agricultural water conservation. Based on this input, Reclamation identified measurement as a critical BMP and incorporated this requirement into the Standard Criteria.

Both Reclamation and the CALFED's Agricultural Water Management Panel address requirements for farm-gate measurement, but the purposes of the measurement differ. The Panel's recommendations focus on the need to aggregate estimates of farm-gate measurement in the context of providing information that will assist state and federal water planning and water balance estimates. The Panel recommendations reflect its conclusion that the hardware currently in place is appropriate for such planning purposes if data are collected and reported.

Independent Panel on Appropriate Measurement of Agricultural Water Use

Convened by the California Bay-Delta Authority

PANEL REPORT

SEPTEMBER, 2003

PANEL REPORT

As directed by the August 2000 CALFED Record of Decision, the California Bay-Delta Authority (Authority) convened the Independent Review Panel on Appropriate Agricultural Water Use Measurement (Panel) in June 2001 to develop a consensus definition of appropriate agricultural water use measurement.

The Panel represents a cross-disciplinary mix of six nationally recognized experts who collectively provide understanding in the areas of measurement technology/hardware; resource economics; groundwater hydrology; technical water policy; water district operations; and, irrigation engineering. A complete listing of Panel members is included in Appendix 1.

This final Panel Report, representing the consensus view of all six panelists, puts forward the Panel's definition of appropriate agricultural water use measurement. The Report represents more than two years of work by the Panel, involving three in-person meetings and numerous teleconferences, frequent communications with staff and consultants to the Authority, and the ongoing involvement of and input from stakeholder representatives. The Panel's final set of deliberations was held June 9, 2003, in Sacramento, California.

The recommended definition builds off the extensive technical analysis conducted by Authority staff and consultants (referred to as the Technical Team). That analysis, shaped by the Panel and presented in Part Two of this document, identified—on a region-by-region basis—the quantitative costs and qualitative benefits likely associated with changes to current agricultural water use measurement practices.

As guided by the Panel, the analysis centered on the potential for measurement improvements at seven specified locations to meet state and federal water management objectives. The seven locations are: 1) surface water diversions, 2) groundwater use, 3) crop consumption, 4) return flow sites, 5) water quality monitoring sites, 6) in-stream flows and 7) farm-gate deliveries. The Panel further directed the Technical Team to use state and federal objectives related to water allocation, water planning, water transfers, and water use efficiency to guide their analyses. The Panel also instructed the Technical Team to note the potential for measurement improvements to contribute to local objectives—such as on-farm water management—but not to use these local objectives as the basis for justifying the definition of appropriate measurement.

Following the general recommendations presented below, a set of "Location-Specific Definitions" summarize the Panel's consensus view on the definition of appropriate measurement at the seven locations under discussion. Each location-specific discussion is summarized into four parts:

ISSUE: This provides a brief description of the rationale for improved measurement.

RECOMMENDATION: This provides a summary of the Panel's recommendation related to what measurement it considers appropriate. The recommendations are characterized as either "basic," "high" or "highest technically practical," to be consistent with terminology used in the detailed technical analysis. (Although the Panel recognizes there are more than just three measurement options for each location, the analysis focused on the three discrete levels introduced above to provide a consistent basis for analysis of costs and benefits.) Taken together, these recommendations constitute the Panel's definition of appropriate measurement.

EXPECTED IMPACT: This outlines the expected impact—both in terms of cost and burden—to local water users. It also identifies where the State is likely to bear the cost.

FOLLOW-ON NEEDS: This lists out key follow-on needs raised during the Panel discussion.

The Panel hopes this Report will be useful to the stakeholder and agency representatives who will now work with the Authority to craft a strategy for implementing this consensus definition.

GENERAL RECOMMENDATIONS

The Panel believes that its consensus recommendations articulate a definition of appropriate agricultural water use measurement that is both grounded in a sound technical analysis and responsive to California's current and near-term needs. Moreover, the Panel believes the definition can serve as a solid foundation for follow-on discussions, to be convened by the Authority, centered on crafting an implementation approach.

Still, as the Authority moves forward with this initiative, the Panel wishes to put forward some important general recommendations related to the Authority's development of an implementation approach.

1. The Panel's final definition of appropriate measurement needs to be summarized in a manner that is straightforward, accessible and supported by the underlying detailed technical analysis.

2. The intent of these recommendations is neither to chart nor preclude any particular implementation path. The Panel recognizes that the implementation task is to be handled in connection with subsequent stakeholder discussions and will be underpinned by the Authority's commitment to regionally sensitive, incentive-driven and cost-effective approaches.

3. Any new approach to measurement must be adaptive and structured in a manner that enables an evolving definition of "appropriateness." This adaptive structure would, over time, account for changes in pertinent factors such as technology and economics. Accordingly, any legislative or regulatory implementation strategy must be carefully crafted to account for, among other things: (1) technological advancements over time; and (2) statewide growth, development, and increases in relative scarcity of water for various beneficial uses over time.

4. As the Authority drafts its implementation approach, the Panel recommends it consider the following: (1) the need to accompany any measurement requirements with an appropriate set of available exemptions, variances and "second-best" approaches; (2) the importance of focusing on how measurement "data" will be turned into "information" useful to governmental and private entities; and, (3) the necessity to provide staffing adequate to carry out certain labor-intensive measurement requirements or to implement approaches that allow requirements to be satisfied in a way that minimizes the labor involved.

5. The Panel has some concern that certain measurement costs included in the analysis (particularly those for groundwater and crop consumption) may have been underestimated by the Technical Team. The Panel urges the Technical Team to either re-review their cost estimates or indicate that further refinement may be required. The Panel does not believe its definition of appropriate agricultural water use measurement is contingent on the precision of cost information provided. In other words, the Panel would have made the same recommendations even if the actual costs are considerably higher than indicated.

Measurement and On-farm Efficiency

PREPARED BY PANELIST JACK KELLER, ON BEHALF OF THE PANEL

Many factors influence a farmer's decision to invest in on-farm water conservation. Aside from the obvious issue of how much the conservation improvement will cost, the farmer will consider: the amount and reliability of the farmer's water right or allocation; the price paid for water delivery, assuming the cost varies with volume received and the price is large enough to provide a meaningful cost signal; the availability of other water sources; the cost of other farm inputs; the relative financial health of the farm; and the potential impact on other water users. In many situations, factors such as the availability of other water sources, the perceived scarcity of water, the cost of other farm inputs, and the relative economic health of the farm overshadow the water delivery and water cost factors.

In California, surface water rights and the resulting supply are treated much the same as property rights and are typically collectively held by water suppliers for their water users. The agricultural water suppliers (irrigation districts) are non-profit public agencies with Boards of Directors that are elected by their water-users. The charges for supplying irrigation water for the lands the district was formed to serve cannot be greater than the cost of operating the district, and water-users favor having low water service costs. Approaches such as tiered pricing can be used to maintain a district's revenue equal to its cost, but these are often resisted by growers for various reasons.

All districts already have some means for diverting their legal share of surface water and distributing it to the farms they serve in a reasonably equitable manner. The delivery efficiency and accuracy of allocations generally depends on the size of the district's dependable water supply relative to irrigation demand during the dry periods, especially in drought years. (For purposes of this discussion, demand is the sum of applied water requirements for comfortably irrigating all the farmland in the district's service area.) The delivery efficiency, measurement and allocation accuracy is typically directly related to the district's relative water supply. The lower the surface water supply is relative to the demand, the higher

Farm-Gate Deliveries

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To this end, the State needs improved estimates of water balance components, including improved information on farm-gate deliveries. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments, and determine whether to direct water use efficiency grant funds and technical assistance toward farm or district improvements.

Farm-gate deliveries are measured using a variety of methods. Approximately 11% of all farm-gate deliveries statewide—primarily in the Sacramento Valley and Eastside of the San Joaquin Valley—are currently at the basic (estimated) level*. These estimated measurements are typically accurate to within ± 15% by volume. (Due to a lack of a comprehensive data reporting system for agricultural water deliveries, the exact volume of water delivered to the 11% is not known at this time.) The remaining 89% of turnouts are directly measured using rated flow structures coupled with duration of use or with continuous or totalizing measurement devices. These are typically accurate to within 6% of volume. However, regardless of the measurement method used, virtually none of this data is currently reported to the State. This information gap hampers state and federal water managers' ability to assess the potential of on-farm water use efficiency improvements.

RECOMMENDATION

It is appropriate to measure the volume of water delivered to farms. Also, it is appropriate for aggregated farm-gate delivery data, whether currently estimated or directly measured, to be collected, managed locally and reported to the State.

Regarding farm-gate measurement methodologies, the Panel believes the current approaches are sufficient to support efficient on-farm water management practices at this time. Although more accurate farm-gate delivery measurement can be an important component of local water management strategies, changes in farm-gate measurement alone will not likely result in significant water management improvements. This is due to the fact that there are many factors that motivate improved on-farm water use efficiency, including knowledge of the volume of water delivered, water price and pricing structure, water availability (or scarcity), the availability of other water sources, the costs of other farm inputs and the financial stability of the farm enter-

* The Panel recognizes that there are many different strategies for measuring farm-gate deliveries. The analysis defined three discrete levels—basic, high and highest technically practical—to provide a consistent basis for the analysis of costs and benefits.

the corresponding efficiency and measurement accuracy. However, where groundwater is available and inexpensive this may not be the case.

Some districts measure, allocate, and deliver the required or available amount of surface water to each farm-turnout; additional deliveries are made only if the grower has arranged for a transfer from within the district. This is done where a limited supply of water is being taken from a dedicated amount of surface storage. However, it is not really an issue where the surface water rights are ample for the area served or there is easy and cheap access to groundwater.

The water requirements during peak growth periods are similar for most crops within a region. However, due to different crop planting dates, crop cycles and irrigation practices, water requirements for different fields can vary considerably during non-peak periods. Consider, for example, the beginning of the season in a rice growing area. The first field planted and flooded in a given area may actually end up recharging the perched water table in the surrounding fields. Thus much more water may be required for it compared to its neighboring fields. In such cases, it may be more equitable or effective to meter the water delivered to the whole area rather than to individual fields.

Districts with sufficient relative water supplies can simplify operations to keep costs low by choosing not to measure and charge according to the volume of water delivered. To cover the costs of operation, they divide the district's total operating cost by the total number of irrigated acres served to arrive at a per acre delivery charge. Then districts would charge each customer according to the number of irrigated acres they have. However, some districts adjust the per acre charge to account for the different irrigation delivery requirements of various crops, soil, and application system types and/or the value of various crops.

In conclusion, water delivery data and water cost signals can be contributing factors in motivating growers to conserve water. However, their efficacy in inducing water conservation is frequently overshadowed by other factors including farm economics, district operations, and overall water availability.

prises. Therefore, given current physical and institutional conditions, it is not necessary to require flows at farm-gates to be more rigorously or accurately measured at this time.

The Panel acknowledges that there would be increased benefits to state goals if all measurements were at the high level. However, the Panel believes that the costs associated with changing those farm gates still at the basic level outweigh the benefits. Panel members also note the following:

- The basic level of farm-gate measurement (which relies on estimated flow rates) is typically accurate to within ± 15% by volume.
- The high level of farm-gate measurement (which relies on collecting flow measurements on rated structures and duration of use data) is typically accurate to within ± 6%by volume.
- The highest technically practical level of farm-gate measurement (which relies on continuous or totalizing measurement devices) is typically accurate to within ± 3% by volume.

Additionally, the Panel notes that incentive-pricing methods (such as tiered pricing) can be used with all current farm-gate measurement methods.

Finally, the Panel acknowledges that state and federal entities may wish to link approval of site or condition-specific grant-funding applications or water contracts to higher levels of measurement. Accordingly, this general statewide recommendation should in no way be considered to preclude or limit higher standards of farm-gate delivery measurement that may be deemed necessary by appropriate entities, including local agencies or authorities, to meet site- or condition-specific needs.

EXPECTED IMPACT

The definition does not represent an upgrade of farm-gate hardware or changes in measurement methodologies, but it does imply an increase in data collection and reporting activities for water suppliers. Water suppliers not currently collecting this information may need to add a half- to full-time staff position for data management.

Note: If and where grant applications are conditioned on applicants' demonstration of higher levels of measurement, some costs may be borne by water users.

FOLLOW-ON NEEDS

None at this time.

Who Pays for Measurement?

PREPARED BY TECHNICAL TEAM MEMBER DAVID MITCHELL, ON BEHALF OF THE PANEL

The Panel's recommendations of appropriate measurement of agricultural water uses is expected to lead to higher costs for measurement compared to existing practices, at least for some locations. The anticipated changes in costs are discussed in detail in Section 4 of this report. This sidebar discusses briefly the question of who would likely incur these costs.

Costs Likely to be Borne by State or Federal Agencies

The Panel's definitions of appropriate measurement for groundwater and crop water consumption entail improvements in the way state and federal water management agencies currently characterize groundwater and crop water uses. This primarily involves improvements in state-sponsored surveying and modeling practices. These are functions that CALFED agencies such as DWR or USBR would perform and pay for. It is not anticipated at this time that agricultural water districts or their customers would be allocated costs for these activities. Similarly, it is anticipated that installation, operation, and maintenance of stream gauging stations would remain within the purview of state and federal agencies and costs associated with these activities—either for flow or quality measurements—would continue to be borne by these agencies.

Costs Likely to be Partially or Completely Borne by Local Water Districts

The Panel's definition of appropriate measurement for major surface water diversions would require surface water diversion points with "basic" or "high" measurement capability to be upgraded to "highest technically practical." This would entail changes to approximately 16% of current major surface water diversion points. Local water districts would likely have primary responsibility for associated costs for the upgrades. However, loan and grant programs administered through the Water Use Efficiency Program may allow some state and federal cost sharing. While the Panel was unable to provide a definition of appropriate measurement of agricultural surface water return flows because of data limitations, it is expected that cost allocation would be similar to major surface water diversions. Water districts would have primary responsibility for necessary infrastructure improvements. However, loan and grant programs administered through either the Water Use Efficiency Program, Ecosystem Restoration Program, or Water Quality Program may allow some state and federal cost sharing.

The Panel's definition of appropriate measurement of farm-gate deliveries does not entail changes to existing delivery hardware, but would require more extensive data collection, management, and reporting. It is anticipated that water districts would pay for district-level data management and administrative costs. Costs associated with state or federal data repositories would be paid for with state or federal funds.

Groundwater Use

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To this end, the State needs improved estimates of water balance components, including improved measurement of net groundwater use. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments, and characterize and assess the sustainable yield of groundwater basins.

State and federal water management agencies currently conduct periodic assessments of groundwater resources for selected basins. However, these analyses are not conducted using consistent methods and are not done frequently enough to adequately characterize groundwater usage. More rigorous and consistent methods are required to determine the amount of groundwater used in various regions of the state and to characterize the extent of overdraft.

RECOMMENDATION

It is appropriate to measure net groundwater use at the high level*—in other words, continuous regional characterization of groundwater volume using two methods simultaneously: (1) development of detailed sub-basin hydrologic balances; and, (2) the water table/specific yield method. Initial cost analyses indicate these methods can be implemented statewide at reasonable cost. However, should the cost of these methods exceed available state resources, the State should focus its effort on those sub-basins with the greatest need for improved groundwater use data.

Additionally, when water transfers involve groundwater substitution, the groundwater wells directly involved in the transfer require the highest technically practical level of measurement (i.e., some form of continuous measurement, monitoring and frequent reporting).

This definition should in no way be considered to preclude or limit higher standards of groundwater measurement that may be deemed necessary by entities with legal jurisdiction over groundwater management, including local agencies or authorities, to meet site- or condition-specific needs.

EXPECTED IMPACT

The expected impacts to water users are likely to be minimal. The proposed method of continuous regional characterizations will mean higher state planning costs: roughly $2 million extra per year. Note: Where continuous measurement of well discharge is required due to water transfers, opportunities may exist for costs to be internalized into the transaction costs borne by the participants to the transfer.

FOLLOW-ON NEEDS

In moving forward with this definition, the Panel recommends that that the Authority reconfirm the incremental costs associated with measurement at the high level (including the costs of data collection and quality control) and amend its costs analysis, as necessary.

As was the case for surface water measurement, the Panel notes that benefits from the proposed improvements in groundwater measurement will be fully realized only if they are coupled with improved measurement of surface water diversions and crop water consumption. Finally, the Panel suggests highlighting the initial groundwater system characterization—i.e., soil types, hydrology—inherent in this definition.

* The Panel recognizes that there are many different strategies for measuring net groundwater usage. The analysis defined three discrete levels—basic, high and highest technically practical—to provide a consistent basis for the analysis of costs and benefits.

Crop Water Consumption

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To accomplish this activity, the State needs improved estimates of water balance components, including improved measurement of crop consumption. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments, determine whether basins are over-allocated, verify water transfers, and adjudicate water rights disputes.

The Department of Water Resources currently estimates crop consumption using indirect methods on a rotating frequency of approximately once every five years for each county. These estimates do not provide information on crop consumption during alternate years. They also are not validated on a large scale and could include error due to lack of information on localized crop consumption variability (such as crop stress, microclimates or other site-specific factors). These uncertainties are of particular concern, given that crop consumption accounts for a significant portion of California's total water use.

RECOMMENDATION

It is appropriate to implement crop water consumption measurement at the high level*—in other words, to incorporate into the State's current estimation procedure the use of satellite-generated remote-sensing of evaporative water consumption, with a monthly time-step, during the full growing season. It is also appropriate for the data to be housed in a state repository.

EXPECTED IMPACT

This measurement approach is not expected to have a direct impact on water users. It does, however, represent a major change in how crop consumption is measured in California. Annual cost of measurement, beyond current state outlays, would be a minimum of $500,000 and would likely be borne by state and federal water agencies.

FOLLOW-ON NEEDS

The Panel believes the additional cost for this level of measurement may prove substantially higher than has so far been projected in the technical analysis to date. Accordingly, in moving forward with this definition, the Panel recommends that the Authority reconfirm the incremental costs associated with measurement at the high level and amend its costs analysis, as necessary.

Additionally, the Panel notes that—to maximize benefits—changes to the measurement of crop consumption need to be coupled with improved accuracy of surface water diversions and groundwater use.

Finally, the Panel believes measurement at the high level may serve other local or regulatory purposes and recommends that the Authority more fully explore and articulate these potential benefits.

* The Panel recognizes that there are many different strategies for measuring crop water consumption. The analysis defined three discrete levels—basic, high and highest technically practical—to provide a consistent basis for the analysis of costs and benefits.

Surface Water Diversions

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To this end, the State needs improved estimates of water balance components, including improved measurement of surface water diversions. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments, determine whether basins are over-allocated and adjudicate water rights disputes.

The State—through the State Water Resources Control Board—receives limited diversion data from water rights permitees. However, the completeness, consistency and accuracy of these reports does not now allow state or federal water management agencies to quantify the amount of water diverted. Quantification of diversions would greatly improve the credibility of and confidence in ongoing water resource initiatives, such as the Bay-Delta Program's integrated storage investigation.

RECOMMENDATION

It is appropriate to measure all major surface water diversions at the highest technically practical level*—in other words, using flow-totaling devices and, if necessary, data loggers and telemetry. It is also appropriate for data to be managed locally and reported to the State.

EXPECTED IMPACT

The impact to water users is expected to be minimal since more than 80% of major surface water diversions are already at the highest technically practical level. Local agencies and the State will have expanded data management requirements. Where upgrades are needed, incremental costs on an annual basis are expected to range between $1,000 and $8,000 per diversion point. The total statewide incremental cost is expected to range from $75,000 to $125,000 per year.

FOLLOW-ON NEEDS

In moving forward with this definition, the Panel recommends that the Authority more clearly define what it means by "major diversions." It further recommends that the Authority confirm the data management costs, if any, associated with those diversions already at the highest technically practical level and amend its costs analysis, as necessary.

Additionally, the Panel notes that although these measurements are necessary, the State would derive even more benefit if groundwater use and crop water consumption measurements are also improved.

* The Panel recognizes that there are many different strategies for measuring surface water diversions. The analysis defined three discrete levels—basic, high and highest technically practical—to provide a consistent basis for the analysis of costs and benefits.

Return Flow

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To this end, the State needs improved estimates of water balance components, including improved information on return flows. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments, verify water transfers and determine the potential for agricultural water conservation to contribute to water quality and in-stream flow and timing objectives.

However, the technical analysis suggests there is a lack of information regarding the location, distribution and type of existing return flow measurement points. There is also a lack of information on the number and type of return flow sites required to adequately collect the needed information. Given these constraints, the Panel concludes there is insufficient information to articulate credible statewide measurement requirements.

RECOMMENDATION

It is appropriate to measure return flow. However, given the lack of information, it is not yet possible to develop a statewide or even region-by-region definition of appropriate measurement for return flow.

EXPECTED IMPACT

There is no expected direct impact to water users at this time, as the State would be responsible for this comprehensive review.

FOLLOW-ON NEEDS

The Panel recommends that the State undertake a comprehensive review to determine existing return flow measurement needs focusing on location specific return flow information requirements. Wherever possible, the analysis should build on existing data sets.

Water Quality

ISSUE

State and federal agencies need accurate information on the existing and desired water quality of agricultural surface and subsurface return flows. This information is required so the State can adequately update the State Water Plan and determine the potential for agricultural water conservation to contribute to water quality objectives.

However, the technical analysis suggests there is a lack of centralized information regarding the location, distribution and type of existing water quality measurement sites. There is also a lack of information on the number and type of water quality measurement sites required to adequately collect the needed information. Given these constraints, the Panel concludes there is insufficient information to articulate credible statewide agricultural water quality measurement requirements.

RECOMMENDATION

It is appropriate to measure water quality. However, given the lack of information, it is not yet possible to develop a statewide or even region-by-region definition of appropriate measurement for water quality.

EXPECTED IMPACT

There is no expected direct impact to water users at this time, as the State would be responsible for this comprehensive review.

FOLLOW-ON NEEDS

The Panel recommends that the State undertake a comprehensive review to determine existing water quality measurement needs focusing on location specific return flow information requirements. Wherever possible, the analysis should utilize existing information sources such as the U.S. EPA's 303(d) list, the State Water Resources Control Board's watershed initiative and the Regional Water Quality Control Boards' Basin Plans.

In-Stream Flows

ISSUE

State and federal agencies need accurate information on the sources and destinations of agricultural water to allow them to adequately manage and plan for current and future needs. To this end, the State needs improved estimates of water balance components, including improved information on in-stream flows. This information is required so the State can adequately update the State Water Plan, make decisions about future storage and conveyance investments and determine the potential for agricultural water conservation to contribute to in-stream flow and timing objectives.

However, the analysis suggests there is a lack of information regarding the number and location of in-stream flow measurement sites required to adequately collect the needed information. Given these constraints, the Panel concludes there is insufficient information to articulate credible statewide in-stream flow measurement requirements.

RECOMMENDATION

It is appropriate to measure in-stream flow. However, given the lack of information, it is not yet possible to develop a statewide or even region-by-region definition of appropriate measurement for in-stream flow measurement.

EXPECTED IMPACT

There is no expected direct impact to water users at this time, as the State would be responsible for this comprehensive review.

FOLLOW-ON NEEDS

The Panel recommends that the State undertake a comprehensive review to better determine its needs for the number and location of additional in-stream flow measurement sites. Wherever possible, the analysis should build on existing information from U. S. Geologic Survey, California Data Exchange Center and local and regional agencies. In addition, the Panel recommends that this analysis begin with an assessment of the costs and benefits of restoring recently discontinued USGS stream gauging stations.

Independent Panel on Appropriate Measurement of Agricultural Water Use

Convened by the California Bay-Delta Authority

TECHNICAL REPORT

SEPTEMBER, 2003

TECHNICAL REPORT, SECTION 1

MEASUREMENT OBJECTIVES & COMPONENTS

SUMMARY

In Section 1, the objectives and components of the definition of agricultural water use measurement are described in detail. These definitions will be used to establish a consistent basis for describing measurement costs and benefits in later report sections.

Briefly, the information derived from agricultural water use measurement can be used to address four objectives at the state and federal levels: 1) planning, 2) water allocation, 3) water transfers, and 4) water use efficiency. In addition, the information can also be used for planning at the local level.

Agricultural water use measurement consists of three components: 1) the flow path measured (referred to as "location"), 2) measurement improvement levels, and 3) data management. Although possible permutations of the three components could create an infinite number of measurement scenarios, the Technical Team has defined discreet levels of the each component to provide a consistent basis for analysis of costs and benefits.

In this analysis, seven measurement locations were identified: 1) surface water diversions, 2) groundwater use, 3) crop water consumption, 4) return flows sites, 5) water quality measurement sites, 6) in-stream flows, and 7) farm-gate deliveries (turnouts). In terms of water quantity, surface water diversions and groundwater use represent water sources; crop water consumption represents a water sink; and return flows, in-stream flows, and farm-gate deliveries (turnouts) represent water flow-paths.

Three different potential levels of measurement were defined for each measurement location: 1) basic, 2) high, and 3) highest technically practical. Each level is defined in terms of its frequency, duration, and accuracy of location measurement and its associated cost of implementation.

A summary of the measurement locations and levels is presented in Table 1.1 on the next page.

Finally, the data management component discusses issues related to the actual data measurement and collection, data storage, quality control and assurance, analysis, and reporting.

INTRODUCTION

This section provides background information on the objectives and components of the definition of appropriate agricultural water use measurement. This information is used in later sections to describe how different agricultural water use measurement alternatives address various measurement objectives. The first part of this section describes the five overall measurement objectives identified for this analysis. The second part describes the three components that define measurement: 1) measurement location, 2) measurement improvement level, and 3) data management.

The four measurement objectives at the state and federal levels are: 1) planning, 2) water allocation, 3) water transfers, and 4) water use efficiency. In addition, the measurement information can be used for planning at the local level. Water planning and water allocation are ongoing tasks in which state and federal agencies have been engaged for decades. Water transfers and water use efficiency programs are more recent efforts that have gained significant attention due to increased demands for the finite water resources.

TABLE 1.1. SUMMARY OF MEASUREMENT LOCATIONS AND LEVELS WITH ASSOCIATED DEFINITIONS

Measurement Location	Potential Measurement Improvement	Summary Definition of Potential Measurement Procedure*
Surface Water Diversion	Basic	• Estimate flow rates for water delivery structures once per year. • Track delivery duration and use flow estimates to calculate volume delivered.
	High	• Inventory and rate structures. • Measure flow rates, on average, three times daily per structure use.
	HTP*	• Inventory and rate structures. • Install flow totaling devices, data loggers, and telemetry where needed.
Groundwater Use	Basic	• Closure factor after estimating crop water consumption, surface water deliveries and surface return flows.
	High	• Continuous regional characterization of groundwater volume using two methods: detailed sub-basin level hydrologic balance and water table method.
	HTP*	• Totalizing flow meters or pump testing coupled with an estimate of the surface runoff or deep percolation of the pumped water. • Install flow totaling devices, data loggers, and telemetry where needed.
Crop Water Consumption	Basic	• Based on an rolling (every five years) inventory of crop acreage, CIMIS and existing crop coefficients.
	High	• Remote sensing (LANDSAT 7) based on a 32 day time step with a 30m resolution during the growing season.
	HTP*	• Remote sensing based on a 16 day (highest frequency of LANDSAT 7 flyover) time step during the irrigation season with a 30m resolution.
Return Flow	Basic	• Estimate flow rates for water delivery structures once per year. • Track delivery duration and use flow estimates to calculate volume delivered.
	High	• Inventory and rate structures. • Measure flow rates, on average, three times per structure use.
	HTP*	• Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry where needed.
Water Quality (Surface and Groundwater)	Basic	• Ad-hoc samples taken without a scheduled sampling interval.
	High	• Frequency of sampling would be prescribed by protocol and constituent of concern.
	HTP*	• Frequency of sampling would be prescribed by protocol and constituent of concern. • Applies to constituents that can be measured on a continuous basis (dissolved oxygen, conductivity, pH, temperature).
In-stream Flows	Basic	• Continuous water level measurement of a cross section that is surveyed annually.
	High	• Continuous water level measurement, of a cross section that is surveyed monthly.
	HTP*	• Continuous water level measurement, of a rated control section consistent with the USGS criteria.
Farm-gate Deliveries	Basic	• Estimate flow rates for turnout structures once per year. • Track delivery duration and use flow estimates to calculate volume delivered.
	High	• Inventory and rate structures. • Measure flow rates, on average, three times daily per structure use
	HTP**	• Inventory and rate turnout structures. • Install flow totaling devices, data loggers, and telemetry where needed.

* All levels include data: collection; quality control and assurance; analysis; reporting; and archiving.
** HTP = Highest Technically Practical

OBJECTIVES

Below is a more detailed look at each of these five primary objectives.

STATE AND FEDERAL WATER PLANNING

State and federal agencies use water measurement to anticipate and plan for changes in supply and demand of water resources. Water measurement information is used to monitor or make changes in the physical and managerial aspects of the storage and conveyance of water. Specifically, water measurement information is used by the State and Federal government to:

- Forecast and verify water supply;
- Meet regulatory requirements for water quality and quantity;
- Conduct feasibility analysis for system improvements;
- Determine timing of water availability for customers;
- Develop budget information for water supply infrastructure;
- Establish water use policies;
- Help monitor conditions of water resources in particular regions to determine whether they should be given special designations and provided with special funding opportunities or regulatory requirements;
- Help monitor status of resources that have already been identified as facing special problems and subjected to special requirements;
- Help inform scientific research work relating to potential improvements in water resource management at the state, district, intermediate-user, and end- user level;
- Facilitate evaluation of the impacts of land use and development activities on water-related resources;
- Facilitate evaluation of availability of water for proposed future land uses;
- Prepare and coordinate contingency plans for different water-year types;
- Uphold the doctrine of public trust.;
- Update the Department of Water Resources Bulletin-160 (State Water Plan) and Bulletin-118 (Ground Water Basins in California); and,
- Develop integrated water resources planning of groundwater and surface water supplies (e.g. conjunctive use, groundwater banking, water transfers, groundwater substitution).

The locations of measurement devices enable the monitoring of inflow and outflow to various facilities and river courses as well as various internal sites that provide adequate coverage of the distribution infrastructure. In addition to flow and volume measurements, water quality measurements are often required. Due to the extensive movement of water throughout the state, planning is required for local, regional and statewide needs.

WATER ALLOCATION

State and federal water suppliers have a fundamental requirement to fulfill water contract obligations and ensure appropriate use of water. In addition, the State has a responsibility to protect and enforce water rights. Measurement information can assist the State to:

- Allocate water in a manner that ensures irrigation water is provided according to water rights or contract status;
- Provide a verifiable basis for administrative and judicial decisions regarding new permit applications and amendments to existing permits, sales of existing water rights, water transfers, adjudications, conjunctive use of surface and groundwater;
- Help coordinate water release schedules for stored water;
- Help determine the availability of water for further appropriation in order to evaluate whether new water right permits may be issued;
- Maintain and administer a system of water rights;
- Comply with legislative mandates; and,
- Comply with interstate compacts and international treaties.

This purpose necessitates gathering data about state, federal and local water supplies, as well as local water requirements. These measurements must ultimately provide for a general accounting of the State's water resources, uses and destinations. These issues vary by region throughout the state.

WATER TRANSFERS

Water measurement information is critical to water transfers. Specifically, water measurement information can be used to:

- Help determine the potential for water transfer programs at local and regional scales;
- Show past consumptive use in order to transfer that amount only;
- Verify water transfer programs, including those which involve groundwater substitution; and,
- Help identify potential hydrologic impacts of water transfers, including changes in return flows to groundwater and surface water bodies.

This information is required because the open and interconnected nature of the water distribution system in California necessitates the verification of any assumption that water transfers are on a one-for-one basis. Complete and accurate information on historic water use—and the hydrologic implications of water transfers—are required to ensure that the proposed transfers are valid and that the transfer does not have third party impacts. Water transfers affect the majority of the agricultural regions throughout the state.

WATER USE EFFICIENCY

State and federal agencies have various regulatory- and policy-driven water use efficiency programs. For example, the Water Use Efficiency element of the CALFED Bay-Delta Program is using incentive grants—among other methods—to aggressively pursue water conservation and recycling at the local level. The CALFED Water Use Efficiency program is based on meeting in-stream flow and timing, water quality and water quantity objectives.

In-stream flow and timing objectives are based primarily on meeting environmental needs; they do not focus on generating new or "wet" water but rather altering the timing of diversions or return flows. "Wet" water represents reduction in irrecoverable losses and can typically be transferred for other uses.

Additional measurement points are expected to provide a foundation to manage and verify the flow-path changes. Water quality objectives are based on reducing pesticides, reducing water temperature for sensitive species and reducing native constituents such as selenium, boron, salt and total organic carbon. Additional water quality measurement points are expected to provide a foundation to manage and verify changes in loading rates and total mass of constituents added to the water. Water quantity objectives are related to increasing the supply of water available for beneficial uses and are met through reducing flows to salt sinks or reducing non-beneficial evaporation or transpiration flows. As with flow and timing, additional measurement points are expected to provide a foundation to manage and verify the flow-path changes for water supply. Measurement of groundwater pumping will also enable water suppliers to improve local groundwater water use efficiency via conjunctive use programs. Appropriate assessment of groundwater resources is necessary to balance available surface water supplies with consumptive use demands.

Accurate information on water use can help CALFED Agencies better design their Water Use Efficiency incentive programs to meet these objectives.

LOCAL PLANNING

Measurement of agricultural water use at the local level is also important and can be used to:

- Improve the distribution surface water supplies to farms;
- Make operational decisions and improvements;
- Accurately charge for water according to the amount used;
- Develop groundwater management plans;
- Develop efficient water management plans;
- Monitor water transfers, including those involving groundwater substitution; and,
- Assess third party impacts due to integrated surface water and groundwater programs.

MEASUREMENT COMPONENTS

Agricultural water use measurement consists of three components: 1) the flow path measured (referred to as "location"), 2) measurement improvement levels, and 3) data management. Although possible permutations of the three components represent an infinite number of measurement scenarios, the Technical Team has defined discreet levels of the each component to provide a consistent basis for analysis of costs and benefits. In this study, seven measurement locations were identified: 1) surface water diversions, 2) groundwater use, 3) crop water consumption, 4) return flows sites, 5) water quality monitoring sites, 6) in-stream flows, and 7) farm-gate deliveries. In terms of water quantity, surface water diversions and groundwater use represent water sources; crop water consumption represents a water sink; and return flows, in-stream flows, and farm-gate deliveries represent water flow-paths.

Improvement levels describe how the measurement location quantity or quality. The current level of measurement in use for any location is assumed to be driven by local need or to meet a regulatory or permitting requirement. Three different potential levels of measurement were defined for each measurement location: 1) basic, 2) high, and 3) highest technically practical. Each particular improvement level is specified as either a physical measurement device or an estimation methodology. The physical measuring devices are further evaluated in terms of the frequency, duration, and accuracy of location measurement; the estimation methodologies are evaluated in terms of their data needs and accuracy of estimation. Both improvement levels are evaluated by associated costs of implementation.

Finally, the data management component discusses issues related to the actual data measurement and collection, data storage, quality control and assurance, analysis, and reporting.

MEASUREMENT LOCATION

In developing the technical analysis, only the major flow-paths are discussed. The Technical Team acknowledges that there is a broad range of additional flow-paths, including deep percolation, canal seepage and open water body surface evaporation. However, the analysis suggests it is not presently technically possible to measure these other flow-paths on a comprehensive basis. The definition of location is presented in a generic sense that describes where a particular measurement is made. For example, surface water diversion is used to represent all geographic locations where surface water is used for irrigation.

SURFACE WATER DIVERSIONS

Surface water diversions are received by water suppliers or individual farmers through structures hydraulically connected to state, federal, or local water project facilities, or to unregulated rivers. Typically these structures are concrete weirs that are designed to carry a specific range of flows. For this study the following measurement levels were defined for this location:

Basic: Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate the volume of water delivered.

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track delivery duration and use flow measurements to calculate the volume of water delivered.

Highest Technical and Practical: Inventory and rate structures. Install flow totaling devices, and, where required, install data loggers and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water delivered.

GROUNDWATER USE

The Panel considered several approaches to defining groundwater use measurement. These deliberations considered the value of information on gross extraction versus net groundwater use. Ultimately, the Panel directed the Technical Team to develop Basic and High levels of groundwater measurement that rely on various indirect methods to estimate net groundwater extraction—and to develop a Highest Technically Practical definition that uses direct methods to measure gross extractions. These definitions are described below.

Basic: Groundwater use measurement is defined by the current method used by DWR as part of their update to California's Groundwater (Bulletin 118) and the Water Plan Update (Bulletin 160).

For each detailed analysis unit (DAU), DWR estimates groundwater use by:

1. Developing estimates of crop water consumption based on land use and climatic information,
2. Adjust the crop water consumption by accounting for effective precipitation, and
3. Obtain net surface water diversions by estimating deep percolation and surface return flows.

The remaining unmet crop water consumption needs are then attributed to groundwater use.

This method can provide confident estimates of net groundwater use for regions where sufficient data is available. However, outside of a few adjudicated or managed groundwater basins, the accuracy of these estimates cannot be evaluated due to the lack of a secondary validation method.

High: Groundwater use is defined as net groundwater extraction and is calculated using a detailed regional water balance that is validated using a water table fluctuation method. The water balance used in this approach is more rigorous than in the Basic level in both the level of detail and the geographic resolution of the balance inputs. It also assumes a level of measurement accuracy of at least "high" in other key water balance components such as surface water diversions and crop consumption.

The input terms of the water balance include deep percolation from applied irrigation and infiltrated precipitation, surface water diversions, seepage from natural and constructed surface water channels, and inter-basin groundwater inflows. The output terms include groundwater pumping, crop consumptive use, return flows (accretions) to surface water channels, and inter-basin groundwater outflow.

Unless directly measured, the input and output components for the water balance must be estimated from sub-balances. For example channel seepage and groundwater return flows are estimated by a surface water balance that may contain many analysis points. In the process of determining all of the components used to estimate storage changes by this approach, a complete hydrologic balance for the sub-basin is performed. The quality of the net groundwater use, as well as those of the other hydrologic balance components, can be indirectly evaluated by comparing the overall storage changes calculated from this method with the storage change calculated in the water table fluctuation method.

The water-table fluctuation method computes groundwater storage changes using records of changing aquifer water level (hydraulic head differences) and aquifer specific yield. This approach is applicable in unconfined aquifers. Information

needed for this method includes groundwater level measurements that are taken on a time interval that is sufficient to capture the seasonal variation in groundwater level. Aquifer specific yield values are taken from well logs or other industry accepted techniques. This method does not provide information on the actual amount of groundwater extracted. It only provides information on the net change in groundwater storage, which is the balance of extraction, recharge, and groundwater transfers to and from neighboring basins. The utility of this information is that it is compared with the storage component calculated in the above method and thus provides validation of that method.

Highest Technically Practical: Groundwater use is defined as gross groundwater extraction (pumping) and is measured directly using totalizing flow or power meters.

This approach uses a direct measurement or estimate of the amount of groundwater pumped. Direct measurement of groundwater pumped from a well through the installation of a flow meter is a high-end option for quantifying the level of water pumped. A wide array of in-line flow meters are available that can be installed at the wellhead.

Another acceptable wellhead method that would provide an estimate of the amount of groundwater pumped is to test the well and pump and relate the test results to a pump factor that can then be used to estimate the volume of water pumped. A pump factor is developed based on a pump test that uses three operating parameters for a pumping plant: the total dynamic head, the total flow being pumped, and the power consumption. Once a pump test has been done the pump factor is used to describe the volume of water pumped for a given amount of power consumption. However, this strategy only allows for an estimation of groundwater pumping where and when the results of a valid pump test and a record of power consumption are available. In addition, the test result relies in part on the continued performance of a mechanical device that is subject to degradation over time.

CROP WATER CONSUMPTION

Crop water consumption is defined as the cumulative amount of water transpired by the crop, retained in its plant tissue, and evaporated from adjacent soil surfaces during its growing season. The following measurement levels were defined for crop water consumption.

Basic: Estimated using crop acreage data from land use surveys, updated every 5 years, and CIMIS crop coefficients and reference evapotranspiration (ET) data.

Crop water consumption estimates for each land use unit are subject to uncertainties due to difficulties involved with accounting for the effects of irrigation management practices, soil and water salinity, water supply adequacy, presence of shallow groundwater, and other spatially variable influences. In addition, crop coefficients are also subject to significant uncertainty due to uncontrollable experimental conditions under which they are derived.

High: Direct measurement using remote sensing based on a 32-day time step (frequency of LANDSAT 7 flyover is 16 days) with a 30m resolution during the growing season.

Remote sensing offers a new means of estimating ET, using digital satellite imagery combined with tested processing algorithms. A Surface Energy Balance Algorithm for Land (SEBAL) is available to calculate the actual ET of each pixel in a satellite image. The ET is calculated based on radiances recorded by digital images, independent from weather and crop and land use information. SEBAL has been tested in several countries around the world, and has provided excellent initial results for Idaho's Snake River Plain region. However, it has not yet been tested in California. It implicitly accounts for all of the factors such as salinity and water management that influence ET estimates.

Highest Technically Practical: Direct measurement using remote sensing based on a 16-day time step (frequency of LANDSAT 7 flyover) with a 30-m resolution during the growing season. This level of measurement is a doubling of the frequency of the process described in the High improvement level.

RETURN FLOWS

Return flows refer to the amount of applied water that is not consumed by plants or evaporation, and that eventually "returns" to an aquifer or surface water body, such as a lake or stream. Return flows include operational spills, surface runoff from agricultural fields, and subsurface drainage. The following measurement levels were defined for return flow sites:

Basic: Estimate flow rates for return flow structures once per year. Track duration of use and use flow estimates to calculate the volume of water "returned".

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track duration and use flow measurements to calculate the volume of water "returned".

Highest Technically Practical: Inventory and rate structures. Install flow totaling devices, and, where required, install data loggers and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water "returned".

WATER QUALITY

This represents a measurement of the useful capacity or impairment of water. This measurement location is important because the information is critical for knowing what the water can be used for. For example many crops suffer yield decline if the irrigation water contains elevated levels of salinity or boron. Knowing the quality of water allows planners to make better decisions. The following measurement levels were defined for Water Quality Measurement Sites:

Basic: Ad-hoc samples taken without a scheduled sampling interval.

High: Frequency of sampling prescribed by protocol and constituent of concern.

Highest Technically Practical: Frequency of sampling prescribed by protocol and constituent of concern. Applies to constituents that can be measured on a continuous basis (dissolved oxygen, conductivity, pH, temperature, turbidity).

IN-STREAM FLOWS

This represents the measurement of flows in streams and rivers. Typically these measurements are made at fixed river gauging stations and are made available for water resources planning and water allocation processes. The following measurement levels were defined for In-stream Flows.

Basic: Continuous water level measurement of a cross section that is surveyed annually. Using the water level information and the survey information the volume of water flowing past the measurement point is estimated.

High: Continuous water level measurement, of a cross section that is surveyed monthly. Using the water level information and the survey information the volume of water flowing past the measurement point is estimated.

Highest Technically Practical: Continuous water level measurement, of a rated control section consistent with the USGS criteria. Using the water level information and the control section information, the volume of water flowing past the measurement point is estimated.

FARM-GATE DELIVERIES (TURNOUTS)

Farm-gate turnouts are the hydraulic structures through which surface water deliveries are received by individual growers. These structures are typically the interface between the water supplier and the individual farm fields. In addition to controlling the delivery of water they are also frequently used to charge the grower for water. The following measurement levels were defined for Farm-gate Deliveries:

Basic: Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate the volume of water delivered.

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track delivery duration and use flow measurements to calculate the volume of water delivered.

Highest Technically Practical: Inventory and rate structures. Install flow totaling devices, and, where required, install data loggers and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water delivered.

DATA MANAGEMENT

A critical component of water measurement is the collection and management of the data generated at measurement locations. This component encompasses: data collection, quality control and assurance, data storage, data analysis, and reporting.

Data collection may be done manually or automatically. If the data collection is done automatically, data may be collected in individual measuring stations, or through the use of telemetry in a central data collection facility. Data may be collected, aggregated, analyzed and processed at the local, regional, or statewide level.

Quality assurance and quality control protocols must be established to ensure that data represent a correct measurement. These protocols establish a well-defined procedure for the collection of flow data and water samples for water quality determination. Thus, data from various locations and taken at different times remain compatible and comparable among each other.

The data obtained must be stored in either handwritten, typed, or digital format. Protocols for various forms, templates, or database structures exist to ensure that data remain readable, are protected against loss or falsification, and to ensure that information about the data (meta-data) are always available so that users other than the data collection agent can read the stored data.

Data analysis protocols and procedures define the process of interpreting the data for planning and management purposes at the individual user, local, regional, or statewide level.

Data are only useful, if they are analyzed, interpreted and eventually reported to the interested customer or to the public. For most data collected by local or state agencies, reporting guidelines exist that prescribe a format for reporting data and information about these data.

TECHNICAL REPORT, SECTION 2

BASELINE CONDITIONS

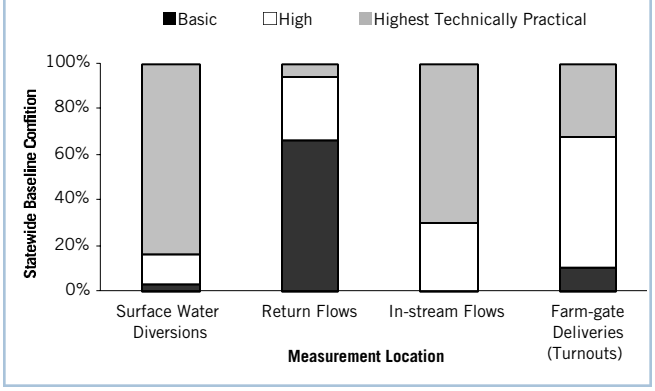
SUMMARY

Section 2 presents the Technical Team's analysis of the baseline conditions for existing agricultural water use measurement.

In order to estimate the incremental cost of achieving a measurement improvement for a measurement location, it is necessary to first establish a baseline of existing measurement devices, infrastructure, and capabilities. Using a number of data sources, a review was performed to establish the baseline condition for each measurement location in the six analysis regions in the state. The methodology for developing the baseline conditions in each analysis region consisted of a review of information describing the devices, infrastructure, and capabilities for providing location measurements at each potential improvement level.

The baseline conditions for Surface Water Diversions, Return Flows, In-stream Flows, and Farm-gate Delivery turnouts are summarized below in Figure 2.1 and in Table 2.1. Baseline conditions for metered and unmetered groundwater wells are presented in Table 2.3. The data describing the baseline conditions for crop water consumption were not amenable to a convenient presentation and are not summarized here. A review of the water quality data did not reveal a comprehensive listing of all sampling protocols and sampling locations.

FIGURE 2.1. SUMMARY OF STATEWIDE BASELINE CONDITIONS BY MEASUREMENT LOCATION



INTRODUCTION

In order to estimate the incremental cost of achieving a measurement improvement for a measurement location, it is necessary to first establish a baseline of existing measurement devices, infrastructure, and capabilities. Using a number of data sources, a review was performed to establish the baseline condition for each measurement location in the six analysis regions in the state.

In this section, we present the following: (1) a brief discussion of the methodology used to develop the baseline conditions, (2) the geographic areas which define the six analysis regions, and (3) a summary of the baseline conditions for each measurement location.

METHODOLOGY

The methodology for developing the baseline conditions in each analysis region consisted of a review of information describing the devices, infrastructure, and capabilities for providing location measurements at each potential improvement level. If measurement devices were amenable to enumeration, the number of measuring devices corresponding to each improvement level was recorded. If the measurement information was not amenable to enumeration, then the baseline conditions for that measurement location are not quantified. The methodology for developing baseline conditions for enumerable measurement devices is given as follows:

Step 1: Review the information describing the devices and infrastructure used to provide physical measurements at each location throughout the state.

Step 2: Count the number of measurement devices in each improvement level for each measurement location.

Step 3: Apportion the measurement improvement level counts to the analysis regions defined for this study.

Step 4: Tabulate the counts of measurement improvement levels for each measurement location for each analysis region.

GEOGRAPHIC REGIONS

The geographic regions used in this study are presented in Figure 2.2 and are described below. The basic regional divisions are based on the major watersheds of the Central Valley. Agricultural areas outside of the Central Valley were consolidated into "Other California" region.

Sacramento Valley: This area is bounded by the American River and Yolo County in the south and Lake Shasta in the north. The primary rivers in this area are the American, Sacramento, Yuba, Bear and Feather. In addition these rivers have numerous tributaries. Drainage from this region returns to the Bay-Delta.

Delta: This area is bounded by the Cosumnes, Calavaras and Mokelumne River watersheds and the Delta. Drainage from this region returns to the Bay-Delta.

Eastside San Joaquin Valley: This area is bounded by the Tuolumne, Merced and San Joaquin River watersheds. The primary rivers in this region include the Stanislaus, Tuolumne, Merced, Chowchilla and the San Joaquin. Drainage from this region returns to the Bay-Delta.

Westside San Joaquin Valley: This area is bounded by the San Joaquin River on the east, the coast range on the west, Fresno County to the south and Stanislaus County to the north. This region is heavily dependent on imported water and there are no major rivers in the region; how-

TABLE 2.1. BASELINE MEASUREMENT CONDITIONS FOR LOCATIONS WITH COUNTS

Type & Region	Irrigated Acres[2]	Number of Measurement Points at Each Location[1] Basic	High	HTP[3]	Total	Basic	High	HTP*
Diversions[4]								
Sacramento Valley	1,623,670	5	5	41	51	10%	10%	80%
Delta	451,548	0	0	11	11	0%	0%	100%
Eastside San Joaquin	1,321,948	0	2	15	17	0%	11%	89%
Westside San Joaquin	906,329	0	0	12	12	0%	0%	100%
Southern San Joaquin	2,305,163	0	14	38	52	0%	27%	73%
Other	1,556,832	0	2	30	32	0%	7%	93%
TOTAL	8,165,489	5	23	147	175	3%	13%	84%
Wells		5				5		
Sacramento Valley	1,623,670		7,900	400	8,300		95%	5%
Delta	451,548		2,200	2,200	4,400		50%	50%
Eastside San Joaquin	1,321,948		5,000	2,100	7,100		70%	30%
Westside San Joaquin	906,329		3,300	1,500	4,800		69%	31%
Southern San Joaquin	2,305,163		9,500	3,400	12,900		74%	26%
Other	1,556,832		5,600	3,500	9,100		62%	38%
TOTAL	8,165,489		**33,500**	13,100	46,600		**72%**	28%
Farm-gate Deliveries								
Sacramento Valley	1,623,670	7,808	23,423	7,808	39,039	20%	60%	20%
Delta	451,548	1,612	3,322	4,813	9,747	17%	34%	49%
Eastside San Joaquin	1,321,948	5,285	15,854	5,258	26,397	20%	60%	20%
Westside San Joaquin	906,329	2,957	316	13,485	16,758	18%	2%	80%
Southern San Joaquin	2,305,163	983	38,432	15,579	54,994	2%	70%	28%
Other	1,556,832	0	14,654	7,601	22,255	0%	66%	34%
TOTAL	8,165,489	18,645	96,001	54,544	169,190	11%	57%	32%

1. Extrapolated from Zillerman, David, et al. July 1998. Private and Institutional Adaptation to Water Scarcity During the California Drought, 1987-1992, ERS Staff paper Number 9802, U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. Groundwater wells from U.S.D.A. Farm & Ranch Irrigation Survey.
2. U.S.D.A. 1997 Census of Agriculture
3. HTP = Highest Technically Practical
4. Assumed one major diversion per district.
5. All wells included in this count are unmetered. The definition of basic and high groundwater measurement relies on regional assessments and assumes no change in mesurement at the well.

ever, there is extensive drainage to the San Joaquin River.

Southern San Joaquin Valley: This area is bounded by the San Joaquin River down to the base of the Tehachapi Mountains. Major rivers in the region include the Kings, Kern, Kaweah and Tule. Except for major hydrologic events, this region does not drain to the Bay-Delta.

Other California: This region covers agricultural areas outside of the Central Valley. This region includes the Imperial and Coachella valleys, the Napa and Sonoma valleys, the Salinas Valley, and areas near San Diego. The coastal areas have significant irrigated acreage but have limited involvement with the Delta.

BASELINE MEASUREMENT CONDITIONS

The baseline conditions for each measurement location are briefly described below.

Surface Water Diversions

Counts of the number of surface water diversion points were obtained from a compilation of water supplier data (UC Berkeley, 1991) which was then updated to 2002 by Provost & Pritchard Engineering. These counts were used along with 1997 Census of Agriculture data to derive estimates of surface water diversions at the analysis region scale. The appropriateness of these estimates was reviewed by the following individuals with extensive regional knowledge:

Lloyd Fryer—Southern San Joaquin Valley
Joe Lima—Eastside San Joaquin Valley
Roger Reynolds—Westside San Joaquin Valley

FIGURE 2.2. APPROXIMATE BOUNDARY OF REGIONS USED IN BASELINE INFORMATION COLLECTION

In addition, a review was conducted of a database developed by the USBR which tracks measurement device information for its CVP contractors. The baseline conditions for surface water diversions are summarized in Table 2.1.

Groundwater Use

A few water suppliers (Alta Irrigation district, Kaweah Delta Water Conservation District, and Kern County Water Agency) were estimating groundwater pumping at the "high" level (i.e. sub-basin scale hydrologic balance).

Groundwater well data were obtained from the Farm and Ranch Irrigation Survey (USDA, 1997). The USDA updates this survey every five years using data collected by the Farm Services Agencies. The numbers of metered and unmetered wells from this survey were then counted for each county and compared with county well counts compiled by DWR using well log completion reports. The county counts were parsed into the analysis regions using approximations of county areas within each region (Table 2.2). No well count information was accounted for outside of the Central Valley. The baseline conditions for groundwater use are summarized in Table 2.3.

Crop Water Consumption

Crop water consumption data was obtained from the DWR Bulletin-160 update staff. Typically, each DWR district office updates its local crop acreage and water consumption every five years and submits them to the DWR headquarters office. Each district office selects the crop coefficients and growing

TABLE 2.2. REGION'S SHARE OF COUNTY IRRIGATED ACREAGE

Region	Percentage of County's Irrigated Acreage 100%	< 100%
Sacramento Valley	Butte Colusa Glenn Placer Sacramento Shasta Sutter Tehama Yolo Yuba	———
Delta	Contra Costa Solano	San Joaquin (50%)
Eastside San Joaquin	Madera	Fresno (30%) Merced (60%) San Joaquin (30%) Stanislaus (60%)
Westside San Joaquin	———	Fresno (40%) Merced (40%) San Joaquin (20%) Stanislaus (40%)
Southern San Joaquin	Kern Kings Tulare	Fresno (30%)

TABLE 2.3. BASELINE MEASUREMENT CONDITIONS FOR COUNT OF METERED & UNMETERED GROUNDWATER WELLS

Region Irrigated	Unmetered Wells	Metered Wells	Ratio
Sacramento Valley	7,900	400	95% / 05%
Delta	2,200	2,200	50% / 50%
Eastside San Joaquin	5,000	2,100	70% / 30%
Westside San Joaquin	3,300	1,500	69% / 31%
Southern San Joaquin	9,500	3,400	74% / 26%
Other California	5,600	3,500	62% / 38%
TOTAL	33,500	13,100	72% / 28%

TABLE 2.4. COUNTS OF IN-STREAM FLOW STATIONS FOR AGRICULTURAL AREAS IN CALIFORNIA

Region	Flow River Discharge	Quality	Quality & Flow	Total
Sacramento Valley	140	43	49	232
Delta	15	37	6	58
Eastside San Joaquin	105	56	9	170
Westside San Joaquin	2	11	12	25
Southern San Joaquin	62	9	9	80
Other California	57	18	36	111
TOTAL	381	174	121	676

season lengths for estimating its local crop water consumption.

Return Flows

Return flow data sources are the same as those for surface water diversions. Baseline conditions for return flows are summarized in Table 2.1.

Water Quality

Water quality data were obtained from a number of state and federal agencies. A review of these data did not reveal a comprehensive listing of all sampling protocols and sampling locations.

In-stream Flows

In-stream flow gauge station data were provided by the USGS, DWR, and US Army Corps of Engineers. The numbers of active and inactive gauge stations in the geographic regions were then counted. These counts represent the baseline conditions for in-stream flows and are summarized in Table 2.4.

Farm-gate Deliveries (Turnouts)

Farm-gate delivery data sources are the same as those for surface water diversions. Baseline conditions for farm-gate deliveries are summarized in Table 2.1.

TECHNICAL REPORT, SECTION 3:
ASSESSMENT OF POTENTIAL BENEFITS

SUMMARY

Section 3 presents the Technical Team's analysis of the potential benefits associated with improved agricultural water use measurement.

The benefits analysis acknowledges and builds off the current baseline. The Authority recognizes that different agricultural water use measurement alternatives provide different benefits to meeting state and federal water resources objectives related to planning, water allocation, water transfers, and water use efficiency. Using the Panel recommendations as a basis, the Technical Team performed an assessment of the potential benefits of each measurement alternative.

The Technical Team conducted interviews with different stakeholder group representatives throughout the state to hear their views on the limitations of current measurement practices and to identify specific changes that might help state and federal managers to better meet their objectives. These interviews also sought to characterize likely benefits to locals, as well as any potential implementation barriers.

In addition to the interviews, the Technical Team reviewed a number of federal, state and local statutes and regulations relevant to agricultural water use measurement. The review focused on identifying gaps and inconsistencies in the current statutes and regulations that hinder the ability of the State to meet its water resources objectives. Coupled with the stakeholder interviews, valuable insight into local implementation of statutes and regulations was gained.

The information obtained from the interviews was synthesized and compiled in a table to display the array of measurement objectives and locations (Table 3.2). The information was synthesized for each region and then aggregated to the state level. The analysis identified changes in the type or quality of the data generated by each water use measurement level. The analysis also identified the information generated by each level and any potential local benefits obtained by the additional measurement information.

The final step of the analysis was to rank the potential benefits of each level. The appropriateness of the rankings assigned to the measurement levels was then reviewed in meetings with representatives from stakeholder groups, and state and federal agencies. A summary of the rankings is given in Table 3.1. Details of the information collected at each measurement location for each level are presented in Table 3.2. The results were aggregated to produce a statewide summary because most of the potential benefits appear to be similar from region to region. Where benefits may likely differ (e.g. regional differences in water quality), these differences are noted in the analysis.

INTRODUCTION

To define appropriate measurement, it is necessary to characterize the expected benefits associated with any possible changes to agriculture water measurement approaches. Estimates of potential benefits were developed for 21 agricultural measurement alternatives. Each measurement alternative is defined by two parameters: (1) a measurement location and (2) a potential measurement level.

The measurement location refers to the physical location or dimension (water quality) of water use. In this study, seven measurement locations were identified: 1) surface water diversions, 2) groundwater use, 3) crop water consumption, 4) return flows sites, 5) water quality measurement sites, 6) in-stream flows, and 7) farm-gate deliveries (turnouts). Measurement improvement level describes how each location is physically measured or estimated. Three measurement improvement levels are used for this analysis: 1) basic, 2) high, and 3) highest

technically practical. A detailed discussion of measurement locations and levels is presented in Section 1.

The characterization of benefits is qualitative in nature. The analysis presented below attempts to articulate—for each of the 21 alternatives (7 locations and 3 potential measurement levels for each location)—the potential benefits for state and federal objectives related to water resources planning, water allocation, water transfers and water use efficiency. In characterizing the benefits, the Technical Team has sought to put forward a rigorous analysis that articulates: what information is acquired from each measurement alternative, how that data can be used to meet state and federal objectives, and why it is of value. The analysis also provides a brief assessment of potential local benefits that may be associated with changes in measurement approaches. (This step is consistent with guidance offered during past Panel discussions that, while the focus of this CALFED Record of Decision commitment should be on statewide objectives, it is important to at least acknowledge and articulate possible local benefits as well.)

The benefits analysis acknowledges and builds on the Technical Team's analysis of the current baseline (Section 2). The Technical Team recognizes that the current approach to measurement is shaped both by local needs and conditions and by existing state and federal mandates. Each region has adopted a cost-effective measurement strategy that generates the necessary data to meet local objectives and requirements.

The Authority recognizes that different agricultural water use measurement alternatives provide different benefits to meeting state and federal water resources objectives. The Technical Team then performed an assessment of the potential benefits of each measurement alternative. The methodology used for this assessment is described below.

METHODOLOGY: ASSESSMENT OF POTENTIAL BENEFITS

The Technical Team qualitatively assessed the potential benefits for each of the seven measurement locations and the three corresponding levels. The strategy used in assessing the benefits of a given measurement level was to assume an entire region was at that level. This was done by applying the following five steps:

Step 1: Identify changes in the type or quality of the data generated by each water use measurement alternative. In other words, what information does each alternative provide?

Step 2: Describe the worth of the additional data generated for each measurement improvement level with respect to the five measurement objectives identified by the Panel. In other words, what information does the additional data provide?

Step 3: Describe any potential local benefits created by the data generated.

Step 4: Using the information gathered from Steps 1-3, assess the potential benefits of each alternative to the measurement objectives according to the following ranking scale:

NONE: Negligible in data worth and negligible benefit to the relevant measurement objective(s).

LOW: Limited in data worth and minimal benefit to the relevant measurement objective(s).

MEDIUM: Moderate in data worth and moderate benefit to the relevant measurement objective(s).

HIGH: Significant in data worth and significant benefit to the relevant measurement objective(s).

HIGH +: Highly significant data worth and highly significant limited to relevant measurement objective(s).

Step 5: Review the appropriateness of the rankings assigned to the measurement improvement levels in meetings with representatives from stakeholder groups, and state and federal agencies.

METHODOLOGY: INFORMATION SOURCES

The sources of information used to assess the potential benefits of the 21 water use measurement improvement levels in Steps 1-5 were acquired through interviews with representatives of stakeholder groups, and state and federal agencies; through review of local, state, and federal statutes and regulations; and through review of measurement practices used by other states. These information sources are described below:

Stakeholder Interviews: The Technical Team conducted interviews with different stakeholder group representatives throughout the state to hear their views on the limitations of current measurement practices and to identify specific changes that might help state and federal managers to better meet their objectives. These interviews also sought to characterize likely benefits to locals, as well as any potential implementation barriers.

Agency Interviews: The Technical Team also conducted interviews with representatives of state and federal agencies responsible for statewide water resources planning and water rights administration. Interviews were structured to hear respondents' views on the lim-

itations of current measurement practices and to identify specific changes that might help them carry out their responsibilities and objectives.

Statutory and Regulatory Review: The Technical Team reviewed a number of federal, state and local statutes and regulations relevant to agricultural water use measurement. The review (Section 3) focused on identifying gaps and inconsistencies in the current statutes and regulations that hinder the ability of the state to meet its water resources objectives. Coupled with the stakeholder interviews, the regulatory analysis provided valuable insight into local implementation of statutes and regulations.

Review of Other States' Approaches: The Panel recommended that the Technical Team review the agricultural water use measurement practices used by other states. Although measurement practices differ from state to state, important insights were obtained through this six-state review (Section 4).

RESULTS

A summary of the measurement level rankings is given in Table 3.1. A detailed summary of the information collected at each measurement location for each improvement level and the associated potential benefits is presented in Table 3.2.

The analysis is assumed applicable statewide, since most of the potential benefits appear to be similar from region to region. Where benefits likely differ (e.g. regional differences in water quality), these differences are noted.

Surface Water Diversions: Improving the surface water diversion measurement level from "high" to "highest technically practical" should improve the following: 1) the determination of water availability, 2) the review of water rights applications, water transfers, and dispute resolutions, and 3) water resources planning by updating Bulletin-160 and Bulletin-118. The highest technically practical level is expected to improve the verification of some types of water transfers. Benefits related to water use efficiency are expected to be low unless the measurement data is coupled with other water balance information necessary to analyze various opportunities. For local agencies, the information can be used for planning and operations.

Groundwater Use: Improving the groundwater use measurement level to "high" statewide is expected to lead to improved estimates of groundwater use. Improved groundwater use measurements are important for conjunctive use investigations, and for updating Bulletin-160 (State Water Plan) and Bulletin-118 (Ground Water Basins in California). The "highest technically practical" should: (1) generate a level of accuracy needed to monitor adjudicated basins and to verify water transfers involving groundwater substitution; and, (2) significantly improve water balance calculations used for planning purposes. However, water use efficiency-related benefits would be impaired, unless coupled with other water balance components necessary to analyze various opportunities for improved water management. For local agencies, the information can be used for planning and operations. In particular, groundwater use information is important when local agencies operate or participate in conjunctive use activities.

Crop Water Consumption: Improving the crop water consumption measurement level to "high" (i.e. remote sensing on a monthly time-step) will provide a direct estimate of crop water consumption rather than an indirect theoretical estimate. Since crop water consumption represents approximately 65% of total consumptive use, the data generated at the high level should significantly improve water balance calculations used for planning purposes. Improving the crop water consumption measurement level to "highest technically practical" (i.e. remote sensing on a 16-day time-step) is not expected to provide significant amount of information over the high level. For local agencies, the information is of use in general planning for estimating water supply needs.

Return Flows: Improving the return flow measurement level to "highest technically practical" can provide important benefits such as monitoring third-party water user impacts, protecting third-party water user rights, estimating more accurate water balances, and providing flow information for water quality investigations. The high level is considered adequate for guiding and tracking water use efficiency investments and performance measures. For local agencies, the information can be used for planning and operations. In particular, local agencies can use this information to plan where to improve district operations to reduce spill.

Water Quality: Improving the water quality measurement level from "basic" to "high" or "highest technically practical" can provide improved information at locations where there exist site- and constituent-specific water quality problems. This additional information can better assist

TABLE 3.1. SUMMARY RANKING* OF POTENTIAL BENEFITS OF AGRICULTURAL MEASUREMENT BY LOCATION & OBJECTIVE

MEASUREMENT		STATE AND FEDERAL WATER MANAGEMENT OBJECTIVES				
Location	**Level**	**Planning**	**Efficiency**	**Allocation**	**Transfers**	**Local Objectives**
Surface Water Diversion	Basic	LOW	LOW	NONE	NONE	LOW
	High	LOW	MEDIUM	LOW	LOW	MEDIUM
	HTP**	HIGH +	MEDIUM	HIGH +	HIGH +	HIGH
Groundwater Use* **	Basic	LOW	LOW	NONE	LOW	LOW
	High	HIGH +	MEDIUM	LOW	HIGH	HIGH
	HTP**	HIGH +	MEDIUM	LOW	HIGH +	HIGH +
Crop Water Consumption	Basic	LOW	LOW	LOW	LOW	LOW
	High	HIGH +	HIGH +	HIGH +	HIGH	HIGH
	HTP**	HIGH +	HIGH +	HIGH +	HIGH +	HIGH
Return Flow	Basic	LOW	LOW	LOW	LOW	LOW
	High	MEDIUM	MEDIUM	LOW	LOW	MEDIUM
	HTP**	HIGH	HIGH	HIGH +	MEDIUM	HIGH
Water Quality	Basic	LOW	LOW	NONE	NONE	MEDIUM
	High	HIGH	HIGH	MEDIUM	HIGH	HIGH
	HTP**	HIGH	HIGH +	MEDIUM	HIGH	HIGH
In-stream Flows	Basic	LOW	LOW	LOW	LOW	LOW
	High	HIGH	MEDIUM	HIGH	HIGH	LOW
	HTP**	HIGH	MEDIUM	HIGH +	HIGH +	LOW
Farm-gate Deliveries	Basic	HIGH	HIGH	NONE	NONE	MEDIUM
	High	HIGH +	HIGH +	LOW	LOW	HIGH
	HTP**	HIGH +	HIGH +	LOW	LOW	HIGH

* Ranking of potential benefits associated with different measurement locations and levels is as follows:
NONE = Negligible benefit to the given objective. LOW = Minimal benefit to the given objective. MEDIUM = Moderate benefit to the given objective.
HIGH = Significant benefit to the given objective. HIGH + = Highly significant to given objective.
** HTP = Highest Technically Practical
*** Characterization of potential benefits based on current law.

state and federal planners in: (1) guiding infrastructure investments, (2) processing water rights applications and permits, (3) determining water transfers, and (4) guiding and tracking water use efficiency investments. The specific benefits of one improvement level over another would occur on a case-by-case basis. To achieve the water use efficiency benefits at the high level, requires coupling with other water balance components necessary to analyze various opportunities for improved water management. To achieve the high water transfer benefits requires coupling with other measurement components required to verify the activities. For local agencies, the information is of use in general planning.

In-stream Flows: Improved stream gauging can improve the ability of the state to meet objectives concerning water resources planning, water availability determination, and water transfers. More accurate data can be used to improve water balances, monitoring and verification of water transfers, and—potentially—estimates of riparian water use. According to the baseline analysis, it is unknown whether the current level of stream gauging is adequate to meet these objectives. Only moderate water use efficiency benefits are likely at the "high" improvement level, even if coupled with other water balance components necessary to analyze various opportunities for improved water management. There appears to be little, if any, incremental benefits for water use efficiency objectives in moving to the highest technically practical level. For local agencies, the information is of use in general planning and operations.

Farm-gate Deliveries (Turnouts): Applying the data collection and management standards to the basic level can yield a high level of benefits for state and federal agencies involved in the guidance and tracking of water use efficiency investments and for planning purposes. Improving the measurement level to "high" can also generate additional benefits, but only if state policymakers implement volumetric pricing or water use efficiency practices which require more accurate farm-gate turnout measurements. Improving to "highest technically practical" would only generate minimal additional benefits over the high level. At the local water planning level, water suppliers can use the information gained from the high measurement level to develop operational, financial and water distribution policies and procedures, and make infrastructure investment decisions. Growers can use the information to schedule irrigations and to make on-farm irrigation improvement decisions. However, little additional benefit would be gained by going to the highest technical practical level.

TABLE 3.2. DETAILED SUMMARY OF POTENTIAL BENEFITS OF AGRICULTURAL MEASUREMENT BY LOCATION & OBJECTIVE

		State Planning		Water Use Efficiency	
Measurement Location	**Level**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**
Surface Water Diversion	Basic	• most all diversions are at this level • provide information on riparian and supplier diversions	• estimate riparian use (LOW)	• most all diversions are at this level • provide information on riparian and supplier diversions	• estimate riparian use (LOW)
	High	• same information as above but with higher accuracy	• estimate riparian use (LOW)	• most all diversions are at this level • provide information on riparian and supplier diversions	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development and monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed • if not coupled (LOW) • if coupled then (MEDIUM) to (HIGH)
	HTP**	• same information as above but with higher accuracy	• planning for future water needs • prepare local, regional, basin water balances • guide infrastructure investment (HIGH +)	• same information as above but with higher accuracy	• minimal incremental benefit (MEDIUM)
Groundwater Use	Basic	• estimate of groundwater use by region	• minimal benefit (LOW)	• estimate of groundwater use by region	• minimal benefit (LOW)
	High	• net groundwater use by sub-basin • sub-basin groundwater hydrologic balances	• planning for future water needs • prepare local, regional, basin water balances • guide infrastructure investment • unprecedented characterization of net gw use • provides independent check that state role is appropriate (HIGH +)	• net groundwater use by sub-basin • sub-basin groundwater hydrologic balances	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development and monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed • if not coupled (LOW) • if coupled then (MEDIUM) to (HIGH)
	HTP**	• gross volume of groundwater pumped from each well • second method of rigorously estimating groundwater use	• groundwater quality modeling • minimal incremental benefit (HIGH +)	• gross volume of groundwater pumped from each well • second method of rigorously estimating groundwater use	• minimal incremental benefit (MEDIUM)
Crop Water Consumption	Basic	• estimates of crop water use by region	• minimal benefit (LOW)	• estimates of crop water use by region	• minimal benefit (LOW)
	High	• unprecedented characterization of crop water use	• planning for future water needs • prepare local, regional, basin water balances • thorough check on crop water use • information about basin efficiency (HIGH +)	• unprecedented characterization of crop water use	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development and monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed (HIGH +)
	HTP**	• same information as above but with higher accuracy	• same as above (HIGH +)	• same information as above but with higher accuracy	• same as above (HIGH +)

* Ranking (in parantheses) of potential benefits associated with different measurement locations and levels is as follows:
NONE = Negligible benefit to the given objective.LOW = Minimal benefit to the given objective. MEDIUM = Moderate benefit to the given objective.
HIGH = Significant benefit to the given objective. HIGH + = Highly significant to given objective.

** HTP = Highest Technically Practical

Water Allocation		Water Transfers		Local Planning	
What Information Do You Get From This Measurement?	**What Is The Benefit Of This Information (Rank*)**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**
• all diversions are at this level • provide information on riparian and supplier diversions	• water right processing needs a higher degree of accuracy (NONE)	• all diversions are at this level • provide information on riparian and supplier diversions	• water transfer verification needs a higher degree of accuracy (NONE)	• all diversions are at this level • provide information on riparian and supplier diversions	• estimate riparian use (LOW)
• most all diversions are at this level • provide information on riparian and supplier diversions	• water right processing needs a higher degree of accuracy (LOW)	• most all diversions are at this level • provide information on riparian and supplier diversions	• most all diversions are at this level (LOW)	• most all diversions are at this level • provide information on riparian and supplier diversions	• improved water management (MEDIUM)
• same information as above but with higher accuracy	• process water right applications, permits and licenses • legitimize the decision making • transparency of decision making (HIGH +)	• same information as above but with higher accuracy	• provide information on riparian and supplier diversions (HIGH +)	• accurate information about diversions	• improved water management • help protect water rights (HIGH)
• estimate of groundwater use by region	• minimal benefit (NONE)	• estimate of groundwater use by region	• minimal benefit (LOW)	• estimate of groundwater use by region	• minimal benefit (LOW)
• net groundwater use by sub-basin • sub-basin groundwater hydrologic balances	• under current state law benefit is (LOW) because state does not currently allocate • moves to (MEDIUM) if state groundwater law changes or basin becomes adjudicated	• net groundwater use by sub-basin • sub-basin groundwater hydrologic balances	• allows monitoring of third party water user impacts • more complete water balances for stream-aquifer interaction, gw extraction that affect local users • for non-groundwater transfers coupled with other water balance measurements (HIGH)	• net groundwater use by sub-basin • sub-basin groundwater hydrologic balances	• supports AB3030 basin water management planning • gives growers more information for water management (HIGH)
• gross volume of groundwater pumped from each well • second method of rigorously estimating groundwater use	• under current state law benefit is (LOW) because state does not currently allocate • moves to (HIGH) if state groundwater law changes or basin becomes adjudicated	• gross volume of groundwater pumped from each well • second method of rigorously estimating groundwater use	• verification of groundwater substitution transfer (HIGH +)	• gross volume of groundwater pumped from each well • second method of rigorously estimating groundwater use	• gives growers information for water management (HIGH +)
• estimates of crop water use by region	• minimal benefit (LOW)	• estimates of crop water use by region	• minimal benefit (LOW)	• estimates of crop water use by region	• minimal benefit (LOW)
• unprecedented characterization of crop water use	• thorough check on crop water use for consumptive use determination • helps define reasonable and beneficial use of water • helps determine if basin is overallocated • coupling potential with other water balance components (HIGH +)	• unprecedented characterization of crop water use	• thorough check on crop water use for consumptive use determination • helps verify changes in consumptive use • coupling potential with other water balance components (HIGH)	• unprecedented characterization of crop water use	• help district internal allocation of water • helps districts in long-term planning • help protect water rights (HIGH)
• same information as above but with higher accuracy	• same as above (HIGH +)	• same information as above but with higher accuracy	• same as above (HIGH +)	• same information as above but with higher accuracy	• same as above (HIGH +)

TABLE 3.2. CONTINUTED

Measurement Location	Level	State Planning: What Information Do You Get From This Measurement?	State Planning: What Is The Benefit Of This Information (Rank*)	Water Use Efficiency: What Information Do You Get From This Measurement?	Water Use Efficiency: What Is The Benefit Of This Information (Rank*)
Return Flow	Basic	• discrete estimate of highly variable flows	• minimal benefit (LOW)	• discrete estimate of highly variable flows	• minimal benefit (LOW)
	High	• discrete estimate of highly variable flows	• planning for future water needs • prepare local, regional, basin water balances • guide infrastructure investment (MEDIUM)	• discrete estimate of highly variable flows	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development & monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed—if not coupled (LOW), if coupled then (MEDIUM) to (HIGH)
	HTP**	• provides substantial improvement in determining return flows	• same as above (HIGH)	• provides substantial improvement in determining return flows	• same as above (HIGH)
Water Quality	Basic	• point in time information of constituent measured	• minimal benefit (LOW)	• point in time information of constituent measured	• minimal benefit (LOW)
	High	• most all water quality stations are at this level • establish water quality baselines • more stations are needed	• planning for future water needs • prepare local, regional, basin water balances • guide infrastructure investment (HIGH)	• most all water quality stations are at this level • establish water quality baselines • number of stations needed dependent on type of WUE project	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development & monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed—if not coupled (LOW), if coupled then (MEDIUM) to (HIGH)
	HTP**	• provides additional data points • applicable to constituents that can be monitored real time	• same as above (HIGH)	• provides additional data points • applicable to constituents that can be monitored real time	• minimal incremental benefit (HIGH +)
In-stream Flows	Basic	• information about in-stream flows	• minimal benefit (LOW)	• information about in-stream flows	• minimal benefit (LOW)
	High	• all existing gauging stations are at this level • more stations needed • improvement in information about water diversion, return and stream flows"	"- prepare local, regional, basin water balances - potential to get information about riparian diversions when coupled (HIGH)	• all existing gauging stations are at this level • improvement in information about water diversion, return and stream flows"	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development & monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed—if not coupled (LOW), if coupled then (MEDIUM) to (HIGH)"
	HTP**	• same information as above but with higher accuracy	• minimal incremental benefit (HIGH)"	• same information as above but with higher accuracy	• minimal incremental benefit (MEDIUM)"
Farm-gate Deliveries	Basic	• provides information about aggregate application values	• delineation of farm and district flows (HIGH)	• provides information about aggregate application values	• delineation of farm and district flows (HIGH)
	High	• same information as above but with higher accuracy	• allows delineation of farm and district flows • preparation of local water balances through aggregate application values (HIGH +)	• same information as above but with higher accuracy	• helps determine if $ spent have generated benefits • helps guide investment $ • enables development & monitoring of better quantified WUE performance measures • must be coupled with other water balance components as needed—if not coupled (LOW), if coupled then (MEDIUM) to (HIGH +)
	HTP**	• same information as above but with higher accuracy	• same as above (HIGH +)	• same information as above but with higher accuracy	• minimal incremental benefit (HIGH +)

Water Allocation		Water Transfers		Local Planning	
What Information Do You Get From This Measurement?	**What Is The Benefit Of This Information (Rank*)**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**	**What Information Do You Get From This Measurement?**	**What Is The Benefit Of This Information (Rank*)**
• discrete estimate of highly variable flows	• minimal benefit (LOW)	• discrete estimate of highly variable flows	• minimal benefit (LOW)	• discrete estimate of highly variable flows	• minimal benefit (LOW)
• discrete estimate of highly variable flows	• water rights determination needs a higher degree of accuracy (LOW)	• discrete estimate of highly variable flows	• water transfer verification needs a higher degree of accuracy (LOW)	• discrete estimate of highly variable flows	• improved water management • help protect water rights • respond to regulatory requirements (MEDIUM)
• provides substantial improvement in determining return flows	• process water right applications, permits and licenses • legitimize and make transparent the decision making process (HIGH +)	• provides substantial improvement in determining return flows	• help state make more valid determination of transferable water • must be coupled with other water balance needs—if not coupled (LOW), if coupled then (MEDIUM) to (HIGH)	• provides substantial improvement in determining return flows	• same as above (HIGH)
• point in time information of constituent measured	• minimal benefit (NONE)	• point in time information of constituent measured	• minimal benefit (NONE)	• point in time information of constituent measured	• reference for leaching determination (MEDIUM)
• most all water quality stations are at this level • establish water quality baselines • more stations are needed	• process water right applications, permits and licenses • legitimize the decision making • transparency of decision making (MEDIUM)"	• most all water quality stations are at this level • establish water quality baselines • number of stations needed dependent on type of transfer	• help state make more valid determination of transferable water • must be coupled with other water balance needs—if not coupled (LOW). if coupled then (MEDIUM) to (HIGH)"	• establish water quality baselines	• help protect water rights • meet regulatory requirements (HIGH)
• provides additional data points • applicable to constituents that can be monitored real time	• same as above (MEDIUM)	• provides additional data points • applicable to constituents that can be monitored real time	• minimal incremental benefit (HIGH)	• same as above with more detail on specific constituents	• same as above (HIGH)
• information about in-stream flows	• minimal benefit (LOW)	• information about in-stream flows	• minimal benefit (LOW)	• information about in-stream flows	• minimal benefit (LOW)
• all existing gauging stations are at this level • more stations needed • improvement in information about water diversion, return and stream flows"	• prepare local, regional, basin water balances • potential to get information about riparian diversions when coupled (HIGH)"	• all existing gauging stations are at this level • more stations needed when transferring • improvement in information about water diversion, return and stream flows"	• provide monitoring and verification of transferred water • protect third party from impacts of transfers (HIGH)"	• same information as above but with higher accuracy	• help protect water rights (LOW)
• same information as above but with higher accuracy	• prepare local, regional, basin water balances • potential to get information about riparian diversions when coupled (HIGH +)	• same information as above but with higher accuracy	• more stations needed • potential to get information about riparian diversions when coupled • provides information on third party impacts (HIGH +)	• same information as above but with higher accuracy	• same as above (LOW)
• provides information about aggregate application values	• minimal benefit (NONE)	• provides information about aggregate application values	• minimal benefit (NONE)	• provides information about aggregate application values	• delineation of farm and district flows (MEDIUM)
• provides information about aggregate application values	• not applicable because water rights determination needs a high degree of accuracy (LOW)"	• provides information about aggregate application values	• not applicable because water rights determination needs a high degree of accuracy (LOW)"	• provides information about aggregate application values	• irrigation scheduling and evaluation • provide ability for volumetric billing and tiered pricing • provides signal to grower regarding value of water • internal district planning • help protect water rights • allows incentive water pricing (HIGH)
• same information as above but with higher accuracy	• same as above (LOW)	• same information as above but with higher accuracy	• in future farm-gate measurement may be used for transfer (LOW)	• same information as above but with higher accuracy	• minimal incremental benefit (LOW)

TECHNICAL REPORT, SECTION 4:

COST ANALYSIS OF AGRICULTURAL WATER USE MEASUREMENT ALTERNATIVES

INTRODUCTION

To aid the Panel in its deliberations, the Technical Team estimated the costs to achieve different levels of measurement capability in the agricultural sector. The primary purpose of the analysis was to highlight the relative costs of alternative measurement intensities so that the Panel could gauge the likely change in cost as measurement intensity increased. Cost estimates were also benchmarked against net farm cash returns to measure the extent of cost impact associated with different measurement improvement levels. The Technical Team believes the cost estimates are accurate within an order-of-magnitude of what the actual cost would be. However, these cost estimates should be considered reconnaissance-level due to uncertainty in some of the baseline data.

METHODOLOGY

Regional and statewide cost estimates were developed for eight agricultural measurement alternatives. Each measurement alternative is defined by two parameters: (1) measurement location and (2) measurement improvement level. Measurement location refers to the geographic location of water use measurement. Four measurement locations were addressed by the analysis: (1) surface water diversions; (2) groundwater use; (3) farm-gate deliveries; and (4) crop water consumption.* Measurement improvement level refers to the frequency and accuracy with which measurements are made. Three measurement improvement levels were addressed by the analysis: (1) basic, (2) high and (3) highest technically practical. The analysis assumed (and available data suggested) that existing infrastructure and practices for the most part would be capable of achieving a "basic" level of measurement for each of the four measurement locations. Farm-gate measurement provides an exception. While existing infrastructure is considered to be sufficient to meet the basic level of measurement for farm-gates, many districts would need to increase their data collection efforts. This additional data collection activity would primarily result in higher staff costs for water districts.

The analysis focused on the incremental cost to achieve increasing levels of measurement given existing baseline conditions. For example, given the existing distribution of measurement improvement levels for agricultural surface water diversions, the analysis estimated the incremental cost to move all diversion points to at least the high level. Thus, the analysis recognized that some diversion points already are at the high level and others are already at the highest technically practical level. The analysis therefore estimated the incremental cost of moving those diversion points currently at the basic level up to the high level. In developing these incremental cost estimates, the analysis attempted to adjust costs to account for existing infrastructure that could be partially or wholly salvaged for use at the higher level of measurement.

ANALYSIS REGIONS

Cost estimates were produced for six regions: (1) Sacramento Valley; (2) Delta; (3) East San Joaquin Valley; (4) West San Joaquin Valley; (5) South San Joaquin Valley; and (6) Rest of State. Table 4.1 shows the correspondence between the five Central Valley regions and irrigated land area within the counties assigned to each region.

* Initially the cost analysis also included return flow, stream and water quality measurements. These locations were dropped from the analysis, however, due to insufficient data on current measurement conditions.

TABLE 4.1. REGION'S SHARE OF COUNTY IRRIGATED ACREAGE

Region	Percentage of County's Irrigated Acreage 100%	< 100%
Sacramento Valley	Butte Colusa Glenn Placer Sacramento Shasta Sutter Tehama Yolo Yuba	———
Delta	Contra Costa Solano	San Joaquin (50%)
Eastside San Joaquin	Madera	Fresno (30%) Merced (60%) San Joaquin (30%) Stanislaus (60%)
Westside San Joaquin	———	Fresno (40%) Merced (40%) San Joaquin (20%) Stanislaus (40%)
Southern San Joaquin	Kern Kings Tulare	Fresno (30%)

DEFINITIONS OF MEASUREMENT INTENSITY

Measurement level definitions used for the cost analysis are presented in Section One (see Table 1.1 on page 32).

BASELINE MEASUREMENT LEVELS

A key step in the incremental cost analysis was estimating existing measurement conditions. This "baseline" condition determined the number of measurement points at each location that would require additional investment to achieve each measurement level. Table 4.2 summarizes baseline measurement capability used for the cost analysis. This is the same baseline information that was presented in Section Two. The estimate of the baseline condition was developed using four sources of information:

1. The distributions of existing measurement capability for district surface water diversions and farm-gate deliveries were derived from water district data compiled by University of California researchers in the early to mid 1990's. While this data provided the best available estimate of existing agricultural water district measurement conditions, two important simplifying assumptions were required to use it for the cost analysis. First, while the data set indicated the number of farm-gate diversion points for each sampled district, it did not show the number of surface water diversion and return points, only the type of technology used to measure flow at these points. Therefore, each district in the sample was assumed to have one major surface water diversion point. Second, to develop the distribution of measurement capability for the entire population of agricultural water districts, the analysis used a simple scaling method based on irrigated acres to extrapolate the sample data.

2. The UC-Berkeley survey of water suppliers was updated by CBDA staff and Provost & Pritchard Engineering of Fresno, California. Updating included adding the types and, in some cases, number of surface water diversions, district-operated groundwater wells and farm-gate delivery structures. Sources of information included the USBR Water Conservation Plans and interviews with local agency personnel.

3. Groundwater well measurement capability by region was derived from a custom data extract from the 1997 Farm and Ranch Irrigation Survey. USDA's Statistical Analysis Service generated this extract at the request of the Technical Team. The data show the estimated number of groundwater wells with and without flow meters.

4. DWR programs for estimating regional crop water consumption and groundwater use provide the baseline condition for those two measurement locations. Because these are regional estimates they are not shown in Table 4.2.

TABLE 4.2. BASELINE MEASUREMENT CONDITIONS FOR LOCATIONS WITH COUNTS

Type & Region	Irrigated Acres[2]	Number of Measurement Points at Each Location[1] Basic	High	HTP[3]	Total	Basic	High	HTP*
Diversions[4]								
Sacramento Valley	1,623,670	5	5	41	51	10%	10%	80%
Delta	451,548	0	0	11	11	0%	0%	100%
Eastside San Joaquin	1,321,948	0	2	15	17	0%	11%	89%
Westside San Joaquin	906,329	0	0	12	12	0%	0%	100%
Southern San Joaquin	2,305,163	0	14	38	52	0%	27%	73%
Other	1,556,832	0	2	30	32	0%	7%	93%
TOTAL	8,165,489	5	23	147	175	3%	13%	84%
Wells		5				5		
Sacramento Valley	1,623,670		7,900	400	8,300		95%	5%
Delta	451,548		2,200	2,200	4,400		50%	50%
Eastside San Joaquin	1,321,948		5,000	2,100	7,100		70%	30%
Westside San Joaquin	906,329		3,300	1,500	4,800		69%	31%
Southern San Joaquin	2,305,163		9,500	3,400	12,900		74%	26%
Other	1,556,832		5,600	3,500	9,100		62%	38%
TOTAL	8,165,489		**33,500**	13,100	46,600		**72%**	28%
Farm-gate Deliveries								
Sacramento Valley	1,623,670	7,808	23,423	7,808	39,039	20%	60%	20%
Delta	451,548	1,612	3,322	4,813	9,747	17%	34%	49%
Eastside San Joaquin	1,321,948	5,285	15,854	5,258	26,397	20%	60%	20%
Westside San Joaquin	906,329	2,957	316	13,485	16,758	18%	2%	80%
Southern San Joaquin	2,305,163	983	38,432	15,579	54,994	2%	70%	28%
Other	1,556,832	0	14,654	7,601	22,255	0%	66%	34%
TOTAL	8,165,489	18,645	96,001	54,544	169,190	11%	57%	32%

1. Extrapolated from Zillerman, David, et al. July 1998. Private and Institutional Adaptation to Water Scarcity During the California Drought, 1987-1992, ERS Staff paper Number 9802, U.S. Department of Agriculture, Economic Research Service, Resource Economics Division. Groundwater wells from U.S.D.A. Farm & Ranch Irrigation Survey.
2. U.S.D.A. 1997 Census of Agriculture
3. HTP = Highest Technically Practical
4. Assumed one major diversion per district.
5. All wells included in this count are unmetered. The definition of basic and high groundwater measurement relies on regional assessments and assumes no change in mesurement at the well.

UNIT MEASUREMENT COSTS

Measurement device unit costs for surface water diversion, groundwater well, surface water return, and farm-gate delivery measurement are shown in Table 4.3. These are estimates of the total annual costs per measurement device and consist of the following cost elements:

1. Capital cost of measurement structures annualized over their average useful lives.*
2. Capital cost of measurement and data logging equipment annualized over their average useful lives.
3. Annual costs to operate and maintain the measurement structures and equipment.
4. Annual costs to compile, process, report, and archive measurement data at the district level.

* All annualized costs used in the analysis are based on a 5.5% discount rate.

Engineering costs estimates developed by Provost & Pritchard Engineering provided the basis for these estimates. A more detailed discussion of the data and assumptions used for the unit costs is contained in the cost information developed to support the Panel's "Interim Meeting" held October 2001. The unit costs shown in Table 4.3 and the baseline conditions shown in Table 4.2 provided the basis for calculating the incremental measurement costs for surface water diversions, return flows, farm-gate deliveries, and the highest technically practical level of groundwater measurement.

Groundwater measurement at the basic and high level are based on regional estimation methods. The costs associated with these two measurement improvement levels represent the upfront capital, operation, and maintenance costs required to perform a simplified regional water balance and a more detailed regional water balance with water-table fluctuation validation, respectively.

Similarly, measurement at the high and highest technically practical measurement levels for crop water consumption

TABLE 4.3. SUMMARY OF UNIT COST COMPONENTS BY MEASUREMENT LOCATION AND IMPROVEMENT LEVEL

		FLOW STRUCTURE				DATA COLLECTION / STORAGE / DELIVERY				TOTAL*
		CAPITAL			O&M	CAPITAL			O&M	
Location	Unit	Cost	Yrs.	$/Yr.	$/Yr.	Cost	Yrs.	$/Yr.	$/Yr.	$/Yr.
MEASUREMENT LEVEL: BASIC										
SW Diversion[1]	Site	$13,500	50	$797	$1,200	$0	0	$0	$113	$2,110
Ground Water[2]	State	$0	0	$0	$0	$20,000	2	$10,832	$1,000,000	$1,010,832
Crop Consumption[3]	State	$0	0	$0	$0	$0	0	$0	$1,200,000	$1,200,000
Farm Gate[4]	Site	$1,000	20	$84	$200	$0	0	$0	$56	$340
MEASUREMENT LEVEL: HIGH										
SW Diversion[5]	Site	$37,000	50	$2,185	$1,200	$0	0	$0	$5,000	$8,385
Ground Water[6]	State	$0	0	$0	$0	$15,242,031	20	$1,275,443	$1,676,623	$2,952,066
Crop Consumption[7]	State	$0	0	$0	$0	$0	0	$0	$510,000	$510,000
Farm Gate[8]	Site	$4,100	20	$343	$600	$20	2	$11	$600	$1,554
MEASUREMENT LEVEL: HTP**										
SW Diversion[9]	Site	$37,000	50	$2,185	$1,200	$26,700	10	$3,542	$2,500	$9,428
Ground Water[10]	Well	$1,300	10	$172	$200	$0	0	$0	$300	$672
Crop Consumption[7]	State	$0	0	$0	$0	$0	0	$0	$1,170,000	$1,170,000
Farm Gate[11]	Site	$6,800	10	$902	$1,200	$20	2	$11	$200	$2,313

* Total $/Yr. = Capital costs plusO&M costs per year of Flow Structure and Data Collection / Storage / Delivery

** HTP = Highest Technically Practical

1. Flow Structure figures from Zillerman, David, et al. July 1998. Private and Institutional Adaptation to Water Scarcity During the California Drought, 1987-1992, ERS Staff paper Number 9802, U.S. Department of Agriculture, Economic Research Service, Resource Economics Division and Provost & Pritchard survey, 2002. Data Collection/Storage/Delivery figures from Imperial Irrigation District Conservation project file, 2001.
2. All figures based on annual cost of existing DWR groundwater analyses. Data collection costs assume ten computers and salary costs for ten staff.
3. All figures based on the annual cost of DWR land use survey.
4. Flow Structure figures based on professional judgment of typical turnout construction and maintenance cost. Data Collection/Storage/Delivery figures reflect the cost of annually calibrating a submerged orifice turnout gate.
5. Flow Structure figures based on cost of long throated flume — Provost & Pritchard projected files, 2002. Data Collection/Storage/Delivery figures based on labor and equipment costs required to measure turnout flow once per day during a 200-day irrigation season. Also includes cost of annual calibration and cleaning.
6. All figures based on fixed cost of obtaining and processing information on aquifer characterization and annual cost of processing variable data such as surface water diversions.
7. See Table S-1 (at the end of this section)for satellite remote sensing.
8. Flow Structure figures based on estimated cost of calibrated slide gate — Provost & Pritchard, 2002. Data Collection/Storage/Delivery figures based on estimated cost of data collection equipment and operation — Provost & Pritchard, 2002. For O&M figures see Table S-2 (at the end of this section).
9. Flow Structure figures based on professional judgment of typical turnout construction and maintenance cost. Data Collection/Storage/Delivery figures based on cost of telemetry system to record as transmit continuous flow data.
10. Flow Structure figures based on typical meter cost ($1,000), installation ($300), and annual operation and maintenance ($200 per year). Data Collection/Storage/Delivery figures based on labor and equipment costs required to measure turnout flow 12 readings per year. Also includes cost of annual calibration and cleaning.
11. Flow Structure figures based on cost of typical turnout meter installation which includes stand with baffle wall ($3,350), open flow totalizing propeller meter ($1,450), data logger and accessories ($2,000), and annual operation and maintenance costs ($1,200). Data Collection/Storage/Delivery figures based on estimated cost of data collection equipment and operation — Provost & Pritchard, 2002.

rely on regional estimation methods. The costs at the basic level are based on existing land use surveys performed by DWR. The high and highest technically practical levels are based on data provided by SEBAL North America, a commercial firm specializing in processing LANDSAT images for crop evapotranspiration. These costs include delivery of crop water consumption data in a geo-referenced format.

SUMMARY OF RESULTS

The results of the cost analysis are summarized in Tables 4.4 through 4.6 and Figures 4.1 through 4.7. Costs in Table 4.4 are inclusive of hardware, data management, and administrative costs.

TABLE 4.4. SUMMARY OF INCREMENTAL MEASUREMENT COSTS ($/YR)

Measurement Location	Measurement Improvement Level High	HTP*
Surface Water Diversions	< $250,000	< $550,000
Groundwater Use	$2–2.5 million	$20–25 million
Crop Water Consumption	< $1 million	< $1.5 million
Farm Gate Delivery	$25–30 million	$175–200 million

* HTP = Highest Technically Practical

SUMMARY OF RESULTS

Please note the following about the information contained in the figures:

1. The figures show the incremental cost to achieve specific measurement levels given the assumed baseline state of measurement. The figures do not show the total cost of measurement, which would incorporate both the baseline and the incremental cost of measurement. The technical team considered the incremental cost of moving to different measurement levels the most relevant to deliberations on measurement policy.

2. Pairs of measurement locations and levels are ranked from lowest to highest incremental cost in the figures. This was done to make the figures easy to interpret. However, the figures should not be read to imply a recommendation regarding the appropriateness of specific measurement location/level pairs. While incremental costs are highly relevant to such a recommendation, incremental benefits must also be taken into account.*

3. Incremental costs shown in the figures are cumulative of all lower cost measurement location/level pairs. The cost of a given location/level pair can be gauged by comparing the difference between its cumulative cost and the cumulative cost of the pair immediately to its left in the figure. Table 4.6 also shows the cost of individual location/level pairs rather than cumulative costs.

TABLE 4.5. LOCATION AND IMPROVEMENT LEVEL NOMENCLATURE USED IN FIGURES 4.2 THROUGH 4.8.

Figure Label	Location	Measurement Level
Divers-Hi	Surface Diversion	High
Return-Hi	Surface Return Flow	High
Gwater-Hi	Groundwater	High
FarmGt-Hi	Farm Gate Delivery	High
Crops-Hi	Crop Water Consumption	High
Divers-Highest	Surface Diversion	HTP
Return-Highest	Surface Return Flow	HTP
Gwater-Highest	Groundwater	HTP
FarmGt-Highest	Farm Gate Delivery	HTP
Crops-Highest	Crop Water Consumption	HTP

4. The figures show cumulative incremental costs in two ways: (1) aggregate cost for the region and (2) per acre cost for the region. Per acre cost is based on the total irrigated acreage for the region reported in the 1997 Census of Agriculture. This approach results in costs being averaged across all irrigated acreage regardless of baseline measurement conditions for particular acreage. An alternative would be to show per acre cost only for acreage affected by the change in measurement level. This was done in Table 4.6, which summarizes the cost analysis results in tabular form, but was not done in the figures because it would invalidate the cumulative per acre incremental costs shown in the figures.**

5. Per acre farm cash returns from the 1997 Census of Agriculture are used to benchmark the magnitude of the calculated incremental costs as well as to show how the cost burden of measurement would vary by region.

The pairs are denoted in the figures according to the nomenclature shown in Table 4.5.

* Underscoring this point is the understanding that it is always possible that a measurement location/level pair with a low incremental cost has an even lower incremental benefit, while one with a high incremental cost has an even higher incremental benefit.

** The cumulative per acre incremental costs would be invalid because the number of affected acres in a region varies according to measurement location. For example, if a change in surface water diversion affects half a region's acreage while a change in groundwater measurement affects only a quarter of it, it would be incorrect to add the two per acre costs together to get a per acre cost of both measurement changes. In this circumstance there would not be one cumulative per acre cost but two. The relevant per acre cost for a given piece of land would depend on its baseline condition.

FIGURE 4.1: STATEWIDE CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION/INTENSITY

Cumulative annual and cumulative average per acre costs are arrayed from lowest to highest cost alternative. The results show that all measurement alternatives considered with the exception of highest technically practical measurement of farm-gate deliveries could be achieved at a cumulative per acre cost of under $7 per year. The incremental cost of moving to the highest technically practical level of measurement for farm-gate deliveries is significant, increasing per acre cost by about $17 per acre. Thus looking at the entire array of measurement options, approximately 75% of the estimated cost is associated with moving to the highest technically practical level of measurement of farm-gate deliveries. The cumulative annual cost to achieve all measurement alternatives would be approximately $220 million per year.* Stopping short of the highest technically practical level of measurement of farm-gate deliveries, the cumulative annual cost would be approximately $54 million per year. These costs are incremental to the baseline costs shown in Table 4.4. The incremental cost of moving all measurement locations to highest technically practical level of measurement would equal about 12% of farm net cash returns (including government income support payments).** The incremental cost of achieving the highest technically practical level of measurement at all locations except farm-gate deliveries would equal approximately 3% of farm net cash returns.***

* Annual costs are based on the annualized value of up-front capital costs plus anticipated annual O&M expenses. Capital costs were annualized using estimates of useful life and a 5.5% discount rate.

** Farm net cash returns are from the 1997 Census of Agriculture.

*** Additionally, incremental costs for high and highest technically practical levels of measurement of farm-gate deliveries may be understated by the figures to some extent. This is because the baseline condition reflects an assessment of the physical capability of turnouts to achieve these levels of measurement but does not take into account whether turnout measurement capability is actually being utilized. If the capability is unutilized there may be some initial cost to put it in service which the analysis does not capture.

FIGURES 4.2–4.7: REGIONAL CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION/INTENSITY

Cumulative annual and cumulative per acre costs are arrayed from lowest to highest cost alternative for each region included in the analysis. These figures replicate Figure 4.1 for each region included in the analysis.

TABLE 4.6: SUMMARY OF RESULTS

Results of the cost analysis for each measurement location, intensity, and region are presented in this table. These data were used to construct Figures 4.1–4.7. However, note that while the figures report cumulative costs from lowest to highest, Table 4.6 shows only the incremental cost to achieve each measurement location/level pair. The costs in the table are not cumulative. As discussed previously, Table 4.6 shows per acre costs in two ways. The first is based on total irrigated acreage for the region. The second shows the average per acre cost only for the acreage that would be affected by the change in measurement. This is referred to in the table as the average cost per affected acre. It shows the average cost per acre assuming the affected acreage would bear the full cost of the change in measurement practice. The reader should note that costs per affected acre should not be added together to get cumulative cost per affected acre for reasons explained earlier.

FIGURE 4.1. STATEWIDE CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

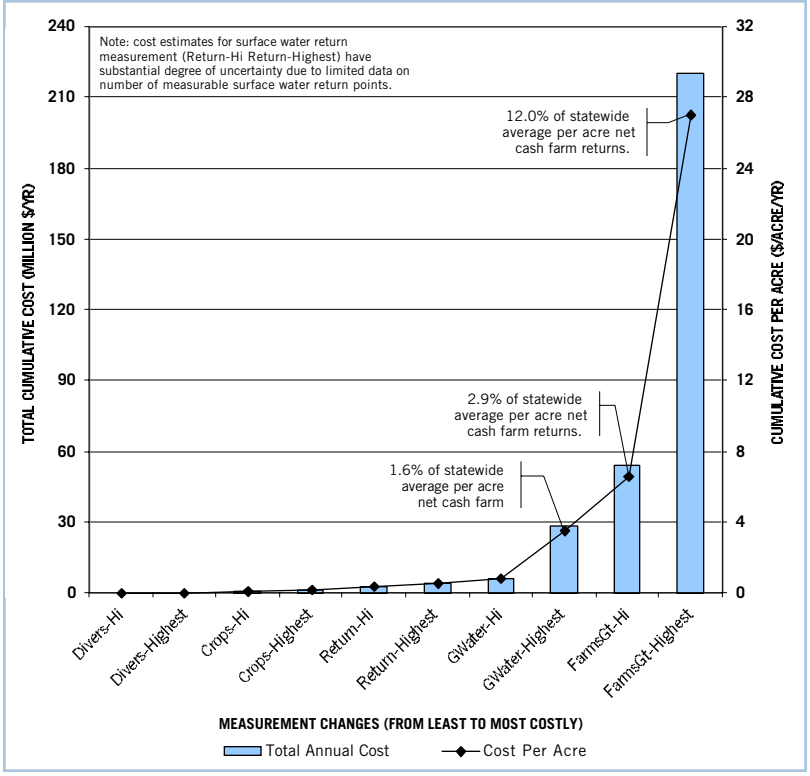


FIGURE 4.2. SACRAMENTO REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

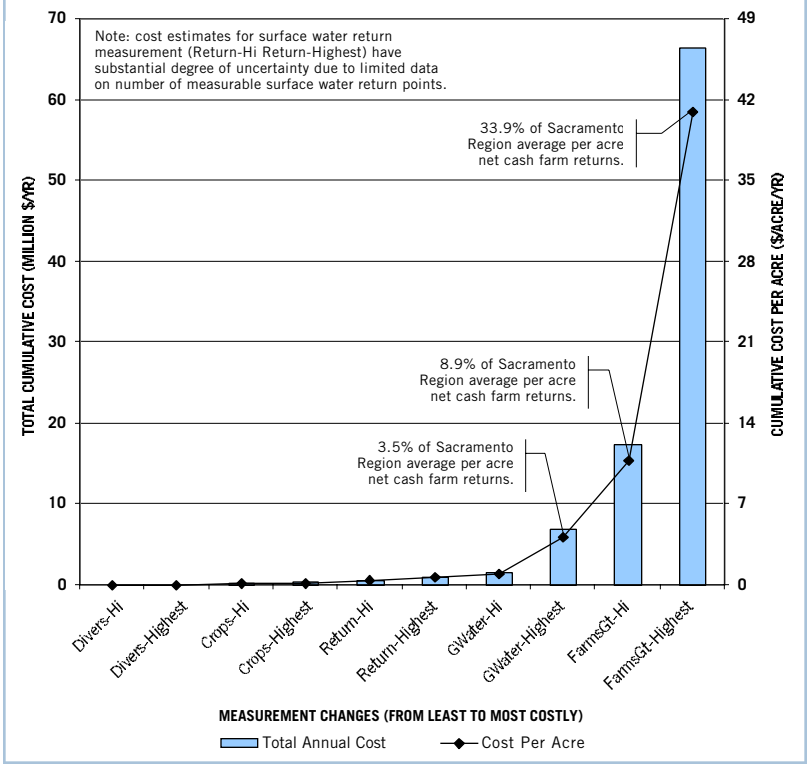


FIGURE 4.3. DELTA REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

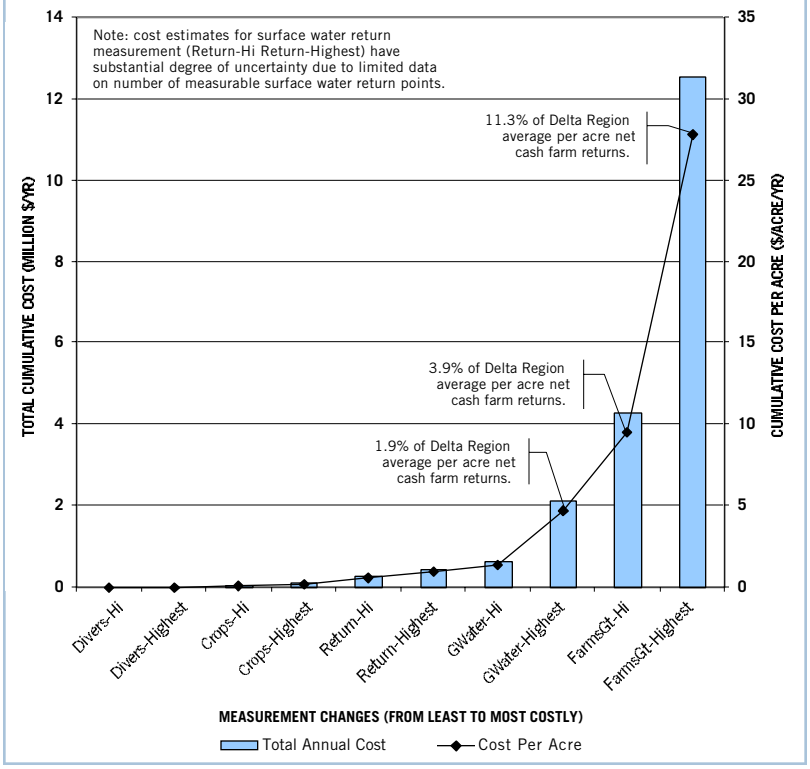


FIGURE 4.4. EASTSIDE SAN JOAQUIN REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

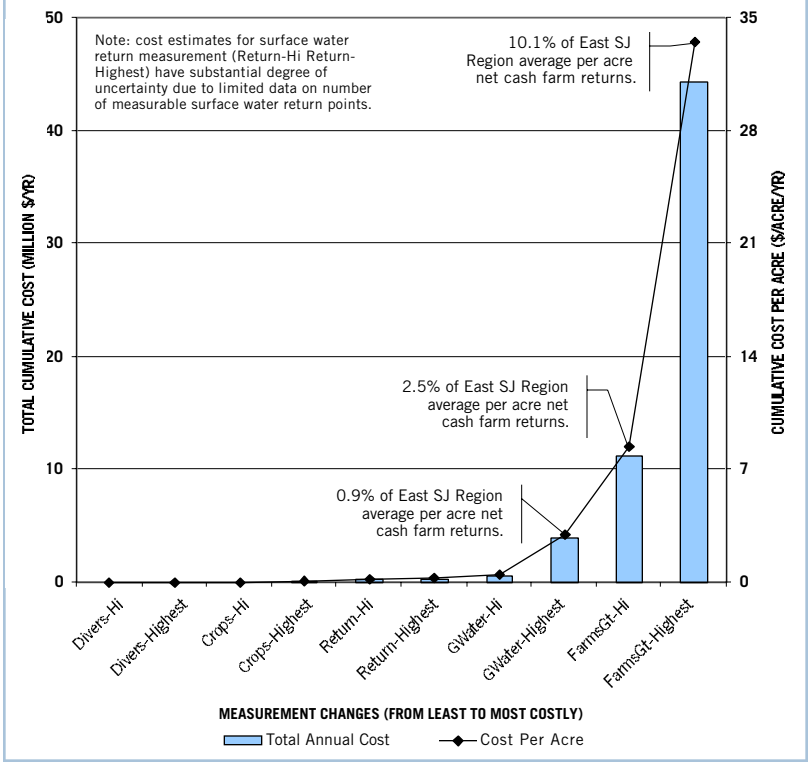


FIGURE 4.5. WESTSIDE SAN JOAQUIN REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

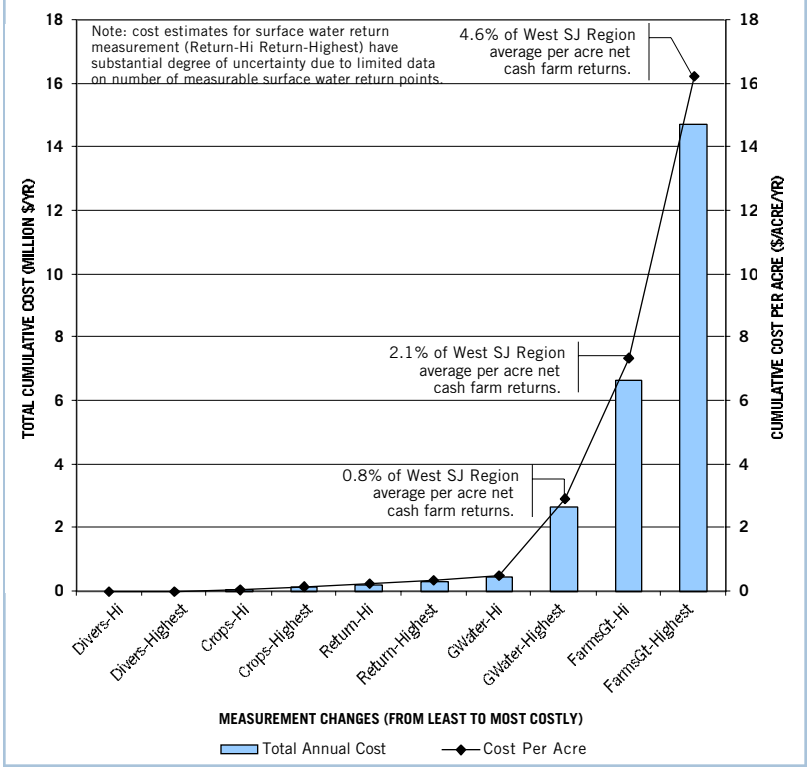


FIGURE 4.6. SOUTHERN SAN JOAQUIN REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

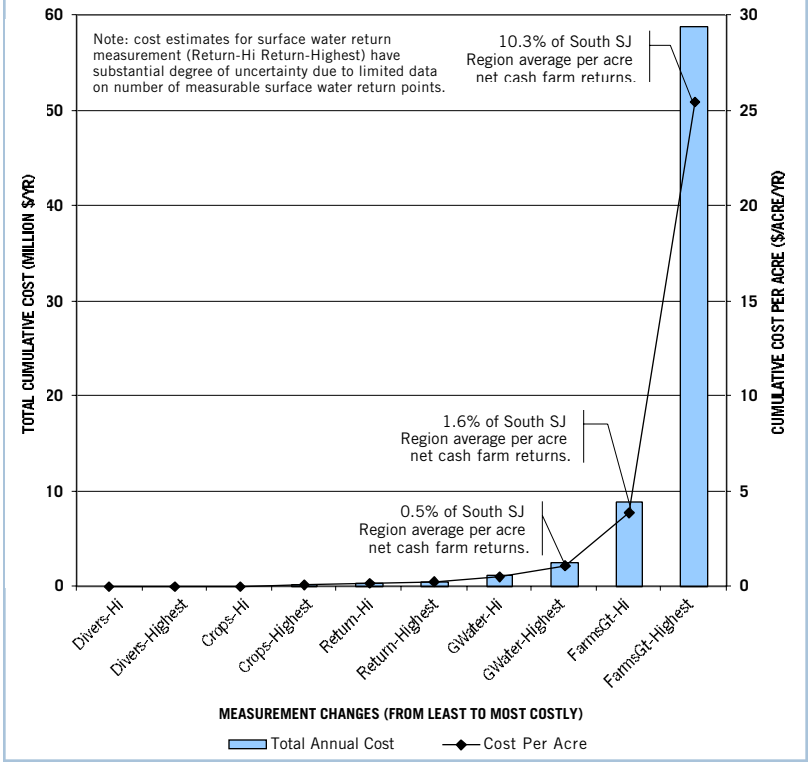


FIGURE 4.7. OTHER CALIFORNIA REGION CUMULATIVE COST OF AGRICULTURAL WATER USE MEASUREMENT BY LOCATION & IMPROVEMENT LEVEL

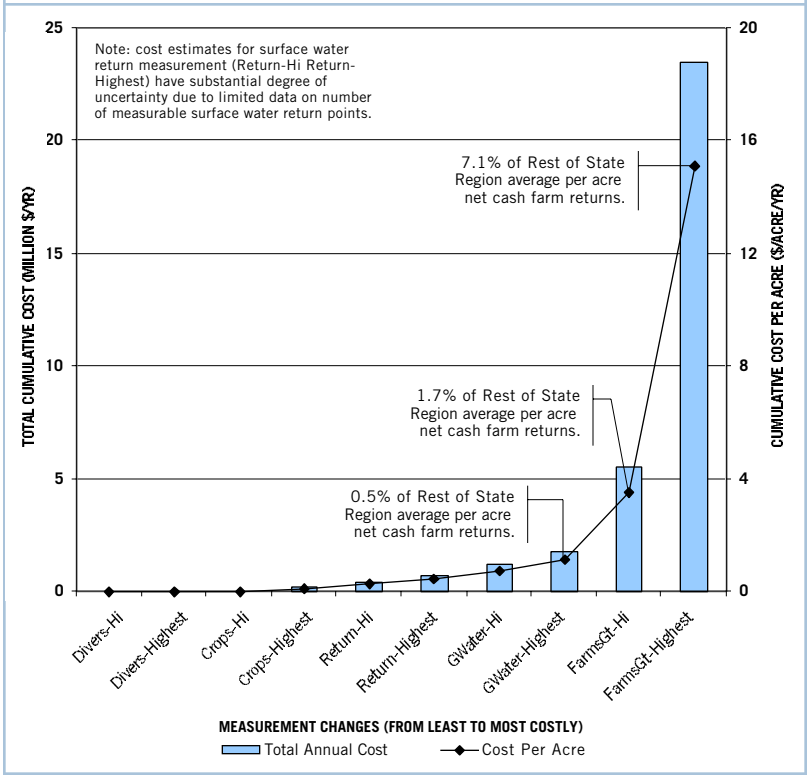


TABLE 4.6. REGIONAL INCREMENTAL COSTS OF MEASUREMENT BY LOCATION AND INTENSITY*

Measurement Location & Intensity	IRRIGATED ACRES		ANNUAL MEASUREMENT COSTS		
	Total	Affected	Total	Per Acre	Per Affected Acre
Sacramento					
Divers-Hi	1,623,670	159,183	$36,371	$0.02	$0.23
Divers-Highest	1,623,670	318,367	$46,793	$0.03	$0.15
Crops--Hi	1,623,670	1,623,670	$100,000	$0.06	$0.06
Crops--Highest	1,623,670	1,623,670	$120,000	$0.07	$0.07
Return-Hi	1,623,670	752,068	$324,585	$0.20	$0.43
Return-Highest	1,623,670	1,623,670	$449,157	$0.28	$0.28
FarmGt-Hi	1,623,670	324,742	$10,586,305	$6.52	$32.60
GWater-Highest	1,623,670	1,545,421	$5,288,798	$3.26	$3.42
FarmGt-Highest	1,623,670	1,298,928	$49,019,117	$30.19	$37.74
Delta					
Divers-Hi	451,548	——	——	——	——
Divers-Highest	451,548	——	——	——	——
Crops--Hi	451,548	451,548	$50,000	$0.11	$0.11
Crops--Highest	451,548	451,548	$60,000	$0.13	$0.13
Return-Hi	451,548	423,315	$163,656	$0.36	$0.39
Return-Highest	451,548	451,548	$194,689	$0.43	$0.43
FarmGt-Hi	451,548	74,680	$2,185,509	$4.84	$29.27
GWater-Highest	451,548	225,774	$1,472,830	$3.26	$6.52
FarmGt-Highest	451,548	228,565	$8,256,670	$18.29	$36.12
Eastern San Joaquin					
Divers-Hi	1,321,948	——	——	——	——
Divers-Highest	1,321,948	142,149	$1,933	$0.00	$0.01
Crops--Hi	1,321,948	1,321,948	$60,000	$0.05	$0.05
Crops--Highest	1,321,948	1,321,948	$70,000	$0.05	$0.05
Return-Hi	1,321,948	617,325	$87,141	$0.07	$0.14
Return-Highest	1,321,948	1,116,173	$115,150	$0.09	$0.10
FarmGt-Hi	1,321,948	264,670	$7,165,551	$5.42	$27.07
GWater-Highest	1,321,948	930,950	$3,347,340	$2.53	$3.60
FarmGt-Highest	1,321,948	793,960	$33,179,166	$25.10	$41.79
Western San Joaquin					
Divers-Hi	906,329	——	——	——	——
Divers-Highest	906,329	——	——	——	——
Crops--Hi	906,329	906,329	$60,000	$0.07	$0.07
Crops--Highest	906,329	906,329	$70,000	$0.08	$0.08
Return-Hi	906,329	475,609	$103,345	$0.11	$0.22
Return-Highest	906,329	906,329	$138,354	$0.15	$0.15
FarmGt-Hi	906,329	159,920	$4,008,974	$4.42	$25.07
GWater-Highest	906,329	623,101	$2,209,245	$2.44	$3.55
FarmGt-Highest	906,329	177,004	$8,036,378	$8.87	$45.40
Southern San Joaquin					
Divers-Hi	2,305,163	——	——	——	——
Divers-Highest	2,305,163	613,007	$14,300	$0.01	$0.02
Crops--Hi	2,305,163	2,305,163	$60,000	$0.03	$0.03
Crops--Highest	2,305,163	2,305,163	$70,000	$0.03	$0.03
Return-Hi	2,305,163	2,062,686	$197,600	$0.09	$0.10
Return-Highest	2,305,163	2,305,163	$236,856	$0.10	$0.10
FarmGt-Hi	2,305,163	41,222	$1,333,381	$0.58	$32.35
GWater-Highest	2,305,163	1,697,600	$6,359,947	$2.76	$3.75
FarmGt-Highest	2,305,163	1,652,161	$49,838,552	$21.62	$30.17
Other California					
Divers-Hi	1,556,832	——	——	——	——
Divers-Highest	1,556,832	113,682	$2,480	$0.00	$0.02
Crops--Hi	1,556,832	1,556,832	$180,000	$0.12	$0.12
Crops--Highest	1,556,832	1,556,832	$270,000	$0.17	$0.17
Return-Hi	1,556,832	1,311,454	$482,784	$0.31	$0.37
Return-Highest	1,556,832	1,311,454	$568,607	$0.37	$0.43
FarmGt-Hi	1,556,832	——	——	——	——
GWater-Highest	1,556,832	958,050	$3,749,021	$2.41	$3.91
FarmGt-Highest	1,556,832	1,025,131	$18,033,152	$11.58	$17.59

* Whereas Figures 4.1–4.7 show cumulative costs of measurement, building from the lowest to highest cost measurement activity, Table 4.6 shows just the cost for each individual measurement location/intensity pair. These are not cumulative costs. Also note that the costs in both the figures and Table 4.6 are incremental in the sense that they do not include the costs already incurred for current levels of measurement.

SUPPLEMENTAL TABLES

TABLE S.1. MEASUREMENT OF CROP WATER CONSUMPTION AT HIGH AND HIGHEST TECHNICALLY PRACTICAL IMPROVEMENT LEVEL USING REMOTE SENSING

	HIGH LEVEL				HIGHEST TECHNICALLY PRACTICAL (HTP)			
Region	**Times/Yr.**	**Images**	**Unit Cost***	**Total Cost***	**Times/Yr.**	**Images**	**Unit Cost***	**Total Cost***
Sacramento Valley	5	2	$10,000	$100,000	11	2	$10,000	$220,000
Delta	5	1	$10,000	$50,000	11	1	$10,000	$110,000
Eastside San Joaquin	6	1	$10,000	$60,000	13	1	$10,000	$130,000
Westside San Joaquin	6	1	$10,000	$60,000	13	1	$10,000	$130,000
Southern San Joaquin	6	1	$10,000	$60,000	13	1	$10,000	$130,000
Other California	6	3	$10,000	$180,000	15	3	$10,000	$450,000
TOTAL				$510,000				$1,170,000

* Costs represent aquisition of LANDSAT images and processing using the SEBAL process

TABLE S.2. OPERATION AND MAINTENANCE UNIT COSTS FOR FARM-GATE DELIVERIES AT THE HIGH IMPROVEMENT LEVEL

Periodic Measurements During Irrigation Season

Staff Labor	
3 measurements per irrigation	3
8 irrigations per year	x 8
Avg. time to perform measurement is 0.5 hrs.	x 0.5
Hourly staff rate including benefits is $36	x $36.00
TOTAL	$432.00
Truck Use	
3 measurements per irrigation	3
8 irrigations per year	x 8
Avg. time to perform measurement is 0.5 hrs.	x 0.5
Hourly cost for 1/2 ton pickup is $13.50	x $13.50
TOTAL	$162.00
TOTAL COST FOR 3 FARM GATE MEASUREMENTS PER IRRIGATION	$594.00

Inventory and Rating of Turnout Structures Cost Assumptions

For the rating and inventory program assume about 0.75 hrs/gate. This would cover collection of rating curves from mfgs and site inspection of turnouts. In the office data would be put into a format and analyzed by a staff engineer and written up. Assume inventory and rating is updated every 15 years.

Staff Labor	
1 inventory per turnout	1
0.75 hrs per inventory	x 0.75
$75 per hour	x $75.00
TOTAL	$56.25
ANNUALIZED COST @ 5.5% DISCOUNT RATE WITH 15 YEAR LIFE	$5.60
TOTAL ANNUAL COST	$599.60

SOURCES: AVERAGE LABOR RATE DEVELOPED BY CBDA; DAYS OF IRRIGATION PER YEAR DEVELOPED BY CBDA; HOURLY COST FOR EQUIPMENT USE FROM UC EXTENSION FARM BUDGETS

TECHNICAL REPORT, 5:
TECHNICAL TEAM PRELIMINARY FINDINGS

SUMMARY

Section 5 presents the Technical Team's preliminary findings and conclusions from its analysis of the projected costs and benefits for each of the measurement improvement levels identified for this study.

The Technical Team prepared these materials in response to the Panel's request that a draft of recommendations be available for review during their final set of deliberations.

Key preliminary conclusions identified by the Technical Team for each measurement location are:

Surface Water Diversions: Improving the surface water diversion measurement level from "high" to "highest technically practical" should improve the following: 1) the determination of water availability, 2) the review of water rights applications, water transfers, and dispute resolutions, and 3) water resources planning by updating Bulletin-160 and Bulletin-118. Improvement to this level is also an incremental, low-cost change from the current approach.

Groundwater Use: Improving the groundwater use measurement level to "high" statewide is expected to lead to improved estimates of groundwater use. This level will also generate useful information for identifying potential conjunctive use opportunities and provide an independent check that the State role in not allocating groundwater is appropriate.

Crop Water Consumption: Improving the crop water consumption measurement level to "high" (i.e. remote sensing on a monthly time-step) will provide a direct measurement of crop water consumption rather than an indirect theoretical estimate. Since crop water consumption represents approximately 65% of total consumptive use, the data generated at the "high" level should significantly improve water balance calculations used for planning purposes.

Return Flows: Given the uncertainty about the number of existing return flow points and the place- and condition-specific needs associated with return flow measurement, the Technical Team does not believe it is possible to project meaningful statewide or per-acre costs for return flow measurement at this time. Additional baseline data is required to assess measurement needs for statewide planning and water use efficiency purposes.

Water Quality: Given the place- and constituent-specific needs associated with water quality monitoring and the current understanding of water quality measurement protocols, the analysis suggests that no statewide upgrade in measurement is appropriate at this time. To further refine statewide data needs, implementing agencies should survey the current measurement of groundwater, surface water streams and agricultural return flow source locations.

In-stream Flows: Based on the analysis, it is unclear if the current measurement approach is sufficient to support planning and water balance objectives. Although many resource managers in state and local agencies have indicated that more stream gauging stations are required, a comprehensive list of station needs does not exist. Implementing agencies should review exist-

ing programs and efforts to better determine the minimum acceptable distribution of measurement points.

Farm-gate Deliveries (Turnouts): The analysis concludes that more consistent farm-gate delivery (turnout) data is needed throughout the state to assist in statewide planning. Although a measurement improvement level upgrade is not being explicitly recommended, an upgrade in data collection and management is being recommended.

The Technical Team also advises that any adopted new approach to measurement must be adaptive and structured in a manner that enables an evolving and nuanced definition of "appropriateness."

The following pages provide a more detailed look at these preliminary findings and conclusions.

OVERVIEW

To determine the "appropriateness" of different agricultural water use measurement strategies, the projected costs and expected benefits for each strategy must be assessed.

Such an analysis presents significant challenges. Most importantly, the analysis must develop credible strategies for analyzing the complexities of the state's current water measurement situation. Water managers measure at different locations using a highly diverse combination of techniques to satisfy varying objectives, local conditions and needs. Additionally, measurement infers more than simply data generation; it encompasses how data is collected and managed. Finally, there are potentially important regional distinctions that must be catalogued and considered. Moreover, the analysis necessitates the comparison of quantitative costs with qualitative benefits.

To address these issues, the Technical Team undertook a region-by-region* analysis that aggregated measurement practices into 21 distinct agricultural water use measurement alternatives: seven measurement locations and three measurement improvement levels, described in Section 1. The Technical Team also refined the costs and benefits analysis in consultation with a number of regional experts.

In this section, a summary is presented of the preliminary conclusions reached from this analysis for defining the appropriateness of agricultural water use measurement. These findings are organized by the seven measurement locations: surface water diversions, groundwater use, crop consumption, return flow, water quality, in-stream flows and farm-gates. For each location, the expected costs and benefits were used by the Technical Team to: 1) define an "appropriate" level of measurement, 2) explain why other levels are not "appropriate", and 3) highlight any region-specific distinctions or other implementation considerations.

In reviewing the preliminary conclusions presented below, attention should be paid to the following considerations:

- For the purpose of this analysis, measurement is defined as the generation, collection, and management of data. Data is generated by a measurement method or device. Measurement encompasses data collection, analysis, quality control and assurance, archiving, and reporting. For water use measurement to be useful, the collected information must be easily accessible to individuals and organizations.

- "Appropriateness" is based on the Technical Team's analysis of the quantitative costs and qualitative benefits associated with generating, collecting and managing data. It does not encompass costs and benefits associated with related district- or on-farm water management changes. (While the Technical Team recognizes the value of incorporating project-specific costs and benefits into the current analysis to ensure scarce resources are allocated wisely, it concludes that it is not feasible to credibly anticipate and quantify local actions at this time.)

- "Appropriateness" is based on the Technical Team's analysis of the quantitative costs and qualitative benefits associated with altering current measurement approaches. The Technical Team recognizes that the characterization of these incremental costs and benefits will likely change over time and must be accounted for in any implementation approach.

- The Technical Team further recognizes that, in cases where the analysis suggests the "appropriateness" is sensitive to slight changes in costs or benefits, basin or project-specific cost and benefit analyses may be warranted to confirm appropriateness and ensure the appropriate allocation of scarce resources.

- The analysis does not attempt to address the issue of who pays for changes in current measurement approaches, as that question is expected to be addressed in post-Panel deliberations. The Technical Team further expects that any approach will be grounded in the CALFED principle of beneficiary

* For the purposes of this analysis, the Technical Team's regional analysis looked at six distinct areas: Sacramento Valley, Delta, Eastside San Joaquin Valley, Westside San Joaquin Valley, Southern San Joaquin Valley, other California. These regions are described in greater detail in Section 1

pays; in other words, locals would be responsible for covering only locally cost-effective actions.

- The analysis is presented as a statewide summary. It was developed, however, based on a regional assessment intended to account for local differences in baseline conditions and anticipated costs and benefits.

FINDINGS AND PRELIMINARY CONCLUSIONS

A summary of the key preliminary conclusions is presented below. The Technical Team prepared these materials in response to the Panel's request that a draft of recommendations be available for review during their final set of deliberations.

These conclusions serve as the basis for the Panel's development of a consensus definition of appropriate agricultural water use measurement. They are summarized here for each of the seven measurement locations.

Before presenting them, several important findings concluded from the analysis are presented as follows:

- Current measurement practices are largely driven by local needs and conditions (e.g. district and on-farm economics, water availability, cropping patterns, and local hydrology) and state and federal regulatory requirements and laws.

- A growing concern among many stakeholder groups over water scarcity throughout the state has led to the recognition that improved measurement of agricultural water use is necessary for planning and policy making efforts to ensure sufficient and reliable water resources in the future.

- To meet state and federal objectives for planning, water availability determination, water transfers, and water use efficiency, the measurement of agricultural water use was deemed most critical at the following seven locations: surface water diversions, groundwater use, crop water consumption, return flow, water quality, in-stream flows, and farm-gate deliveries. Accuracy needs vary and depend on the measurement location and the use of the information.

- Measurement practices and needs related to tracking surface water diversions, crop water consumption, and farm-gate deliveries do not vary significantly from region to region. Groundwater use is often estimated using various methods across regions, except in adjudicated basins where more accurate data is collected. Conversely, measurement and accuracy needs associated with return flow, water quality, and stream-gauging are extremely region-specific and tend to defy a single statewide approach.

- Measurement information is not collected and managed using the same methods in all regions of the state. For example, with farm-gate deliveries, information is available to allow districts to bill customers for the amount of water used. (Billing may be done using volumetric methods or based on crop type being grown.) However, some districts do not routinely store this information for analytic purposes. Thus, it is not possible to aggregate information across regions to generate reliable estimates of water use and budgets or make objective decisions regarding public funding of district or on-farm improvements.

These findings along with the costs/benefit analyses outlined in Sections 3 and 4 serve as the basis for the preliminary conclusions detailed below. In preparing these conclusions, the Technical Team has attempted to distinguish between what it characterizes as findings of fact (i.e. costs associated with measurement techniques) and assertions of judgment (i.e. what level of measurement is needed to meet stated objectives).

SURFACE WATER DIVERSIONS

Surface water diversions are received by water suppliers or individual farmers through structures hydraulically connected to state, federal, or local water project facilities, or to unregulated rivers. Typically these structures are concrete weirs that are designed to carry a specific range of flows. For this study the following improvement levels were defined for this location:

Basic: Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate the volume of water delivered.

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track delivery duration and use flow measurements to calculate the volume of water delivered.

Highest Technically Practical: Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water delivered.

The analysis suggests that roughly 4% of surface water diversions statewide are currently measured at the "basic" improvement level, 16% are at the high level, and 80% are at the highest technically practical level. There are some slight regional variations. In the Sacramento Valley, the number of water suppliers at the basic and high levels is slight-

ly greater than elsewhere. This distinction accounts for most of the variation in the state.

Based on the baseline conditions for surface water diversions and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reports the following preliminary findings:

- Most surface water diversions statewide are currently measured at the high level. Based on the analysis, the Technical Team finds that this level is unable to provide the accuracy needed to credibly resolve water rights disputes and determine water availability.

- Upgrading surface water diversions to the highest technically practical level is considered by the Technical Team to be "appropriate" statewide because it: 1) enables a more efficient and effective review and approval of water rights applications, water transfers, and dispute resolutions, 2) enables more effective planning (i.e. Bulletin-160 forecasting), and 3) represents an incremental, low-cost change from the current approach.

- The analysis indicates that upgrading all surface water diversions to the highest technically practical level would cost on an annual basis approximately $100,000/yr or $0.01 per acre if averaged across statewide irrigated acreage. Costs are not evenly distributed across analysis regions, however. Roughly 70% of the statewide cost would occur within the Sacramento Valley. Most of the balance would occur on the eastside of the San Joaquin Valley.

- Implementing agencies should consider threshold cutoffs for small riparian users. Although the extent of small riparian diversions is unknown, it is assumed that they represent only a minor user of water.

GROUNDWATER USE

Groundwater use refers to the actual amount of applied groundwater consumed by the crop (i.e. the evapotranspiration of applied groundwater). For this study the following improvement levels were defined for this location:

Basic: Calculated as the closure factor in a crop water balance after estimating crop water consumption, surface water deliveries and surface return flows.

High: Based on a continuous regional characterization of groundwater volume using two methods: a detailed sub-basin scale hydrologic balance and the water-table fluctuation method.

Highest Technically Practical: Totalizing flow meters or pump testing coupled with an estimate of the surface runoff and deep percolation of the pumped water. Install flow totaling devices, data loggers, and telemetry.

The analysis suggests that approximately 28% of groundwater wells dedicated to agricultural uses currently have totalizing flow meters. Information about the volume pumped, in nearly all instances, remains with the well owner. There are a few sub-basins with detailed groundwater budgets developed by local water suppliers or governments. Most sub-basins in the state are measured at the basic level with the information self-reported for Bulletins 160 and 118.

Based on the baseline conditions for groundwater use and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reports the following preliminary findings:

- Most groundwater use is currently estimated from surface water deliveries, crop water consumption, and self-reported Bulletin-118 data. The consistency and reliability of data generated through this approach is unknown. Most existing adjudicated basins rely on self-imposed measurement using totalizing flow meters, with data reported to a local water master.

- Improving the groundwater use measurement level to "high" statewide is expected to lead to improved estimates of groundwater use. Improved groundwater use measurements are important for conjunctive use investigations, and for updating Bulletin-160 (State Water Plan) and Bulletin-118 (Ground Water Basins in California). The highest technically practical level should generate a level of accuracy needed to monitor adjudicated basins and to verify water transfers involving groundwater substitution.

- The analysis suggests that the cost on an annual basis of upgrading measurement of groundwater use to the high level is approximately $2 million per year or $0.25 per acre. Regional cost differences are a function of the size of the groundwater sub-basins within a region.

- Though the "highest technically practical" measurement is capable of generating significantly better data (both in detail and reliability), the Technical Team believes that the cost associated with this level of measurement appears warranted only in adjudicated basins (through a locally driven effort) or if the state plans to manage or allocate groundwater. The cost analysis suggests the cost on an annual basis of mov-

ing all groundwater use measurement to the highest technically practical level is approximately $22 million per year or $3 per acre. Per acre costs are highest in the Sacramento Valley and Delta analysis regions, where the proportion of metered wells to total wells is lowest. In these two regions, costs average about $3.25 per acre; in the other regions, costs average closer to $2.50 per acre.

- Based on the analysis, the Technical Team believes that measuring groundwater use and crop water consumption at the high level along with measuring surface water diversions at the highest technically practical level will significantly improve the accuracy of water balance calculations. Moving all groundwater wells to the highest technically practical level will provide the user with more information regarding water use that can subsequently be used to improve on-farm management.

CROP WATER CONSUMPTION

Crop water consumption is defined as the cumulative amount of water transpired by the crop, retained in its plant tissue, and evaporated from adjacent soil surfaces during its growing season. For this study the following improvement levels were defined for this location:

Basic: Estimated using crop acreage data from land use surveys, updated every 5 years, and CIMIS crop coefficients and reference evapotranspiration data.

High: Direct measurement using remote sensing based on a 32-day time step (frequency of LANDSAT 7 flyover is 16 days) with a 30m resolution during the growing season.

Highest Technically Practical: Direct measurement using remote sensing based on a 16-day time step (frequency of LANDSAT 7 flyover) with a 30-m resolution during the growing season.

Statewide, crop water consumption is currently measured using the basic level as outlined above. Differences in the methods used by the DWR district offices to report crop water consumption account for regional differences.

Based on the baseline conditions for crop water consumption and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reports the following preliminary findings:

- The vast majority of data is currently developed using theoretical crop water consumption estimates for five-year intervals. This approach results in indirect measurement with unknown accuracy.
- Improving the crop water consumption measurement level to "high" (i.e. remote sensing on a monthly time-step) will provide a direct measurement of crop water consumption rather than an indirect theoretical estimate. Since crop water consumption represents approximately 65% of total consumptive use, the data generated at the high level should significantly improve water balance calculations used for planning purposes. It will also provide information necessary to determine basin-wide water availability and to make water management investments most needed to meet the state's current and future water demands.
- The analysis suggests that the total cost on an annual basis of upgrading measurement of crop consumption use to the high level is approximately $0.5 million per year or $0.06 per acre. Cost differences are based on land area changes across regions.
- The analysis suggests that upgrading crop water consumption measurement to the "highest technically practical" level is not warranted, as the Technical Team does not expect it to yield a meaningful improvement in information value over the high level. Moreover, such a shift would represent an increase in cost to approximately $0.08 per acre.
- Though the effectiveness of remote sensing has been demonstrated in some areas, given the limited application of this new technology, implementing agencies should carefully track the effectiveness of this approach to identify unexpected cost or effectiveness considerations
- Measuring crop water consumption and groundwater use at the high level along with measuring surface water diversions at the highest technically practical level is expected to significantly improve the accuracy of water balance calculations.

RETURN FLOWS

Return flows refer to the amount of applied water that is not consumed by plants or evaporation, and that eventually "returns" to an aquifer or surface water body, such as a lake or stream. Return flows include operational spills, surface runoff from agricultural fields, and subsurface drainage. For this study the following improvement levels were defined for this location:

Basic: Estimate flow rates for return flow structures once per year. Track duration of use and use flow estimates to

calculate the volume of water "returned".

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track duration and use flow measurements to calculate the volume of water "returned".

Highest Technically Practical: Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water "returned".

It is not possible to currently characterize baseline measurement of return flows, as data is diffuse.

For return flows measurement, the Technical Team has reports the following preliminary findings:

- There is currently no systematic approach statewide for measuring return flows nor does a new statewide approach seem warranted given the extremely place-specific water transfer and water availability needs associated with this data.

- In some instances—for example, when there is a need for better monitoring and prevention of third-party water-user impacts or better water balances—it may be conditionally appropriate to upgrade measurement of return flows to "highest technically practical." In those instances where better data is needed, the analysis indicates that "high" is not good enough due to the highly variable nature of return flows.

- Given the uncertainty about the number of existing return flow points and the place- and condition-specific needs associated with return flow measurement, the Technical Team does not believe it is possible to project meaningful statewide or per-acre costs for return flow measurement at this time.

- Sufficient background information for return flow locations was not available in a comprehensive and consistent manner. Moreover, there was a consensus among the individuals contacted for interviews that there is insufficient measurement information for return flow locations.

- Return flow information improves the overall water balance by providing more detail about local activities that contribute to public waterways. Also, due to the connection with public waterways, there is a strong tie between stream gauging, water quality and return flows. This information can also be used to support water quality investigations and TMDL development.

- The analysis suggests that additional baseline data is required to assess measurement needs for statewide planning and water use efficiency purposes. Accordingly, implementing agencies should review existing programs and efforts to determine additional statewide measurement needs, if any, associated with objectives such as water quality, quantifiable objectives, and stream loading.

WATER QUALITY

Water quality represents a dimension of measurement that is used to establish the useful capacity or impairment of water (both surface and groundwater). For this effort, the following improvement levels were defined for this location:

Basic: Ad-hoc samples taken without a scheduled sampling interval.

High: Frequency of sampling prescribed by protocol and constituent of concern. This covers constituents for which there are no existing sampling devices that can directly measure the target constituents (for example, selenium sampling from the Westside of the San Joaquin Valley using a predetermined sampling interval).

Highest Technically Practical: Frequency of sampling prescribed by protocol and constituent of concern. Applies to constituents that can be measured on a continuous basis (dissolved oxygen, conductivity, pH, turbidity and temperature) using a device that directly measures the constituent.

The place- and constituent-specific nature of water quality measurement makes it difficult to characterize the current state of measurement. In addition, there are a multitude of discretely monitored sites that operated for specific time periods. In many cases, the water quality information collected is not housed in a publicly accessible manner.

Based on these baseline conditions and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reaches the following preliminary findings:

- Currently all three measurement levels are used for monitoring in-stream, return flow and groundwater quality. The specific approach is driven by local and state needs.

- Like return flows, given the largely place- and constituent-specific needs associated with water quality monitoring and the current understanding of water quality measurement protocols, the analysis suggests that no statewide upgrade to measurement is considered appropriate at this time.

- Given the place- and condition-specific needs associated with water quality measurement described above, the Technical Team does not believe it is possible to project meaningful statewide or per-acre costs for water quality measurement at this time.

- Water quality information improves the overall water balance by providing more detail about local activities that contribute to public waterways. Also, due to the connection with public waterways, there is a strong tie between stream gauging, water quality and return flows. This information can also be used to support water quality investigations and TMDL development.

- To further refine statewide data needs, implementing agencies should survey the current measurement of groundwater, surface water streams and agricultural point-source return. More baseline data is needed.

IN-STREAM FLOWS

In-stream flows represent the measurement of flows in streams. For this study the following improvement levels were defined for this location:

Basic: Continuous water level measurement of a cross section that is surveyed annually. Using the water level information and the survey information the volume of water flowing past the measurement point is estimated.

High: Continuous water level measurement of a cross section that is surveyed monthly. Using the water level information and the survey information the volume of water flowing past the measurement point is estimated.

Highest Technically Practical: Continuous water level measurement of a rated control section consistent with the USGS criteria. Using the water level information and the control section information, the volume of water flowing past the measurement point is estimated.

The analysis suggests that in-stream flows statewide are currently measured at either the high level (30%) or the highest technically practical (70%) level. Little, if any, measurement occurs at the basic level. Regional differences are due primarily to the lack of stream gauging stations in some regions.

Based on the baseline conditions for in-stream flows and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reports the following preliminary findings:

- Currently, only the two highest levels of measurement are used for in-stream flows. Based on the analysis, it is unclear if the current measurement approach is sufficient to support planning and water balance objectives. Although many resource managers in state and local agencies have indicated that more stream gauging stations are required, a comprehensive list of station needs does not exist.

- Any statewide upgrade in measurement approach is conditional upon the state developing a better understanding of the reasonable distribution of measurement points. If warranted, upgrades are expected to focus on "high" or "highest technically practical" since "basic" does not generate sufficient quality data for water balances or water availability and water transfer issues.

- The analysis suggests that costs on an annual basis associated with stream gauging ranges from $10,000 to $20,000 per station. However, given the limited understanding associated with stream gauge measurement described above, the Technical Team does not believe it is possible to project meaningful statewide or per-acre costs for stream flow measurement as it relates to agricultural water uses at this time.

- Stream gauging information improves the overall water balance by providing more detail about local activities that contribute to public waterways. Also, due to the connection with public waterways, there is a strong tie between stream gauging, water quality, and return flows. This information can also be used to support water quality investigations and TMDL development.

- Implementing agencies should review existing programs and efforts to better determine the minimum acceptable distribution of measurement points.

FARM-GATE DELIVERIES (TURNOUTS)

Farm-gate turnouts are the hydraulic structures through which surface water deliveries are received by individual growers. These structure are typically the interface between the water supplier and the individual farm fields. For this study the following improvement levels were defined for this location:

Basic: Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate the volume of water delivered.

High: Inventory and rate structures. Measure flow rates, on average, three times per day. Track delivery duration and use flow measurements to calculate the volume of water delivered.

Highest Technically Practical: Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry. The electronic equipment provides a continuous data stream that is used to determine that volume of water delivered.

The analysis suggests that approximately 11% of farm-gate deliveries statewide are currently measured at the basic level, 57% at the high level, and 32% at the highest technically practical level. Regional variations are the greatest for this measurement location. The Sacramento Valley and the eastside of the San Joaquin Valley have more of the basic level of measurement, whereas the other regions of the state have a greater amount of the "high" and the "highest technically practical" farm-gate deliveries.

Based on these baseline conditions and the analysis of expected benefits and costs associated with changes to the current measurement approach, the Technical Team reaches the following preliminary findings:

- Currently, all three levels are used to measure farm-gate deliveries, though most farm-gate delivery infrastructure is capable of generating high or highest technically practical level data. However, discussions with local, state and federal representative suggest varied on-farm use of the infrastructure capabilities. In other words, while the infrastructure may be in place, it appears that many water users are not collecting or using the data or reconfirming the accuracy of the measurement devices.

- Regardless of the method or device being used, the analysis suggests it is important to foster more uniform use of existing infrastructure and generate more consistent data statewide, as reporting of aggregated data is expected to assist statewide planning. Although this level does not represent an upgrade of farm-gate hardware, it does imply an increase in data collection and reporting activities for many water suppliers.

- If statewide policymakers decide to implement volumetric pricing or water use efficiency practices, the analysis suggests that more accurate farm-gate data is needed. The current high level method used by many end users appears, based on the analysis, to be sufficient and appropriate to inform such an approach; "basic" is not. The annual cost associated with shifting turnouts from the basic to the high level is expected to range from $20 million to $30 million statewide or $25 to $35 per affected acre. For those that are at the basic level, a literature review suggests that this approach may be sufficient to mandate incentive (but not volumetric) pricing.

- Based on the analysis, the Technical Team believes that the highest technically practical measurement level is cost prohibitive in most situations—on an annual basis cost estimates range by region from $10 million to $50 million and from $20 to $50 per affected acre (This wide range is due to regional differences in number of turnouts that would need to be converted and acres served per turnout.)—and is not a necessary condition to support volumetric pricing. It is also not seen to be essential in meeting other state or federal water management objectives. Finally, in some localities, farm-gate measurement provides a poor approximation of field-level water consumption. This is especially true in regions that use flow-through irrigation where return flow from one field is used on another.

PRELIMINARY CONCLUSIONS

In this study, the Technical Team has reached four preliminary conclusions concerning a definition of appropriate measurement for consideration by the Panel.

Preliminary Conclusion One: The following measurement improvement levels are recommended statewide: 1) highest technically practical level for surface water diversions, 2) high level for groundwater use, 3) high level for crop water consumption, and 4) at least the basic level for farm-gate deliveries coupled with improved data management. The Technical Team recommends that the Panel deem these "appropriate".

Preliminary Conclusion Two: The Technical Team recommends that the Panel deem the existing measurement levels for return flow, water quality, and stream gauging "conditionally appropriate". These measurement locations required more detailed and ongoing evaluation of their place- and constituent-specific needs.

Preliminary Conclusion Three: The Technical Team recommends that the Panel deem the two following improvement levels "conditionally appropriate":

- Highest technically practical level for groundwater use. This makes sense in locally initiated adjudicated basins or if the state plans to manage or allocate groundwater resources at the basin level.

- High level for farm-gate deliveries. This may be appropriate if volumetric pricing or water use efficiency practices are implemented.

Preliminary Conclusion Four: Any new approach to measurement must be adaptive and be structured in a manner that enables an evolving and nuanced definition of "appropriateness." Accordingly, any legislative or regulatory implementation strategy must be carefully crafted to account for the following:

- The impact of evolving technologies, shifting attitudes, and changing costs and benefits on the appropriateness of different measurement strategies;

- The need in some instances to undertake more project-specific, costs/benefits analyses, particularly in those cases where implementation costs are high and locally unique costs and benefits exist; and,

- The involvement of affected stakeholders in designing implementation approaches that account for local sensitivities and differences.

Additionally, a review of the agricultural water use measurement approaches used by six other states suggests three additional implementation considerations to keep in mind. They are:

- First, any specific requirement that agricultural water use be measured must always be associated with an appropriate set of available exemptions, variances, and "second best" approaches.

- Second, when establishing any requirement that agricultural water use be measured, it is equally important to focus on how the measurement "data" will be turned into "information" that is useful to governmental and private actors.

- Third, when designing an approach to agricultural water use measurement, it is important to consider the necessity to provide staffing adequate to carry out certain labor-intensive measurement requirements or to implement approaches that allow requirements to be satisfied in a way that minimizes the labor involved.

The Technical Team looks forward to discussing its findings and preliminary conclusions with the Panel..

Independent Panel on Appropriate Measurement of Agricultural Water Use

Convened by the California Bay-Delta Authority

APPENDICES

SEPTEMBER, 2003

APPENDIX A:

OVERVIEW OF AGRICULTURAL WATER USE MEASUREMENT PANEL PARTICIPANTS

Below are biographies for the six panelists serving on the Agricultural Water Use Measurement Panel. Panelists were selected, with the involvement and concurrence of representatives from affected stakeholder communities, for their collective ability to provide the necessary expertise and their individual ability to participate in a collaborative, productive and timely manner.

NAOMI DUERR is currently Director of the Environmental Monitoring and Assessment Department for the South Florida Water Management District (SFWMD), a $524-million agency responsible for flood control, environmental restoration, water allocation, and protection of natural systems in a 16-county area covering 10 million people. Ms. Duerr received her BS in Geology and her Masters of Public Administration and Policy (MPA) with a specialty in water policy, both from the University of Nevada—Reno. She is a Certified Professional Geologist.

Ms. Duerr manages a staff of 200+ engineers, scientists, chemists, geologists, programmers, and analysts in 4 divisions. Her areas of responsibility include hydrology and hydraulics, water quality analysis, water quality monitoring, and hydrologic information systems and assessment. The information stream from these areas supports on-going water management and periodic reports, including the comprehensive, annual Everglades Consolidated Report. Under her direction, the Department also provides information for decision making on major initiatives such as rule development for phosphorus concentrations in the Everglades and implementation of the Comprehensive Everglades Restoration Plan.

From 1993 to 2000, Ms. Duerr was the State Water Planner and head of the Division of Water Planning in Nevada, the driest state in the nation. There she led a team of scientists and planners in developing the state drought plan, state water conservation plan, and regional watershed plans, and initiated the state natural resource plan and state floodplain management program. The Nevada State Water Plan, developed under her direction, was selected as the Most Notable Document of the Year 2000 by the National Conference of State Legislators. As State Water Planner, Ms. Duerr was also responsible for implementing data analysis and water education programs, and a $50 million program of grants for water conservation and construction of water systems. Prior to joining the state of Nevada, Ms. Duerr was the Deputy Director of the Regulation Department at the St. Johns River Water Management District in Florida, where she led the effort to develop new water conservation and water measurement rules. Professional honors include: Florida Regulatory Person of the Year by the Florida Rural Water Association, and recipient of the Golden Pinecone Award, Nevada's most significant environmental achievement award.

THOMAS HARTER is currently Associate Cooperative Extension Specialist in Subsurface Hydrology and a faculty member of the Department of Land, Air, and Water Resources at UC Davis. He received his Ph.D. in Hydrology from the University of Arizona, where he also was a Fulbright Scholar and Harshbarger Fellow. He earned his M.S. in Physical Geography/Hydrology from the Universities of Freiburg and Stuttgart, Germany.

Dr. Harter is conducting research on deep vadose zone characterization and groundwater resources assessment through groundwater flow and contaminant transport modeling. He is serving as principal investigator for developing a regional

groundwater and surface water model of a 1,500-square-mile watershed in the San Joaquin Valley, a risk analysis of production aquifer salinization in the Western San Joaquin Valley, and an assessment of groundwater quality impacts from animal farming operations. As a technical reviewer for the state of Arizona, he has advised on project design and research implementation involving groundwater development projects. Dr. Harter has also taught numerous courses on topics including Groundwater Flow and Transport Modeling, Vadose Zone Modeling, and Applied Groundwater Hydrology.

Dr. Harter is a member of the American Geophysical Union, the European Geophysical Society, the International Association of Hydrologic Sciences, the National Ground Water Association, and the Groundwater Resources Association of California. He has contributed articles to numerous publications and conferences including "Environmental Science and Technology," "Journal of Hydrology," and "Water Resources Research."

STEVE HATCHETT is an economist specializing in agriculture, water resources, and mathematical and statistical analysis. He received his Ph.D. in Agricultural Economics from the University of California at Davis in 1984. Dr. Hatchett is owner of Western Resource Economics, a private consulting firm specializing in agriculture and water resources in the western U.S. Prior to opening his private practice in early 1999, Dr. Hatchett served as economist and project manager in the Sacramento office of CH2MHILL for more than 11 years.

Dr. Hatchett has led the economic analysis for numerous projects related to agricultural water use. Clients include the Bureau of Reclamation (Mid-Pacific and Pacific Northwest Regions), CALFED, California Dept. of Water Resources, and many local agencies. Dr. Hatchett is a recognized expert in the economics of irrigated agriculture. Among his activities, he has: Developed a comprehensive database of agricultural land use, water use, production, prices, and costs for the Central Valley of California; Evaluated the trade-offs between on-farm irrigation costs, water use, and management for major Central Valley crops; Evaluated the effects of changes in water supply and pricing on irrigation water use in California; Assisted CALFED in quantifying agricultural water conservation targets and developing guidelines to evaluate water conservation proposals.

Dr. Hatchett has prepared numerous project reports, articles in professional journals, and presentations to professional conferences.

CHRIS KAPHEIM is General Manager of Alta Irrigation District, a San Joaquin Valley water supplier encompassing 130,000 acres in Tulare, Fresno and Kings Counties. There are approximately 4000 farmers that may utilize surface water within the district. Mr. Kapheim received his B.S. in Soil Science from California Polytechnic State University, S.L.O. Mr. Kapheim is also a graduate of Class XXVI of the California Agricultural Leadership Program.

Mr. Kapheim has been a member of the Tulare County Planning Commission since 1987, and has been recognized for his efforts to conserve agricultural land in association with planned growth and development by being named "California Planning Commissioner of the Year" representing the central region of California. The Kapheim family has been farming in Dinuba, California, since 1907. Mr. Kapheim is the fourth generation to actively partake in the farming enterprise. Currently Kapheim farms grows grapes and plums.

Mr. Kapheim has been active in political issues serving as Chairperson of Governor Davis' Central Valley Subcommittee on Air and Water, which resulted in two economic summits located in Fresno and Bakersfield. Currently Mr. Kapheim is co-founder and Chairperson of the Kings River Water Political Action Committee. Mr. Kapheim is also Co-Chairperson of the Kings River Legislative Committee. Mr. Kapheim is active on water conservation issues helping formulate and being a member of the Agricultural Water Management Council.

JACK KELLER is currently Professor Emeritus of Agricultural and Irrigation Engineering for the Biological and Irrigation Engineering Department at Utah State University, and founder and Chief Executive Officer of Keller-Bliesner Engineering, LLC. He received his Ph.D. in Irrigation Engineering from Utah State University, his M.S. in Irrigation Engineering from Colorado State University, and his B.S. in Civil Engineering from the University of Colorado.

During his tenure at the University, Dr. Keller has taught and carried out research in sprinkle and trickle irrigation, and served as Department Chairman from 1979 through 1985. While at the University he was the Co-Director (from 1978 through 1989) of the multi-disciplinary Water Management Synthesis Projects, funded by the U.S. Agency for International Development, to provide socio-technical assistance for transferring irrigation technologies worldwide. Before joining Utah State University in 1960, Dr. Keller was the Chief Irrigation Engineer for W.R. Ames Company, a leading manufacturer of irrigation equipment in the United States. Over the years, he has served as a consultant to the Ames Company, as well as several other irrigation system manufacturing companies.

Through his public and private activities, Dr. Keller has provided advisory services on irrigation matters in over 60 different countries in all regions of the world. He is recognized as an international expert in the field of irrigation technolo-

gy transfer, irrigation and irrigated agricultural policy formulation, and the problems associated with improving irrigated agriculture in both developed and developing countries. He is currently serving as Senior Policy Advisor in Kansas, Egypt, Morocco and California, and as a Senior Integrator with CALFED's Water Use Efficiency Program. He previously served as a panel member on the Independent Review Panel on Agricultural Water Conservation Potential. Dr. Keller is also serving as the Science Liaison Officer and Fellow for the international Water Management Institute, which is one of the CGIAR Centers. He is the author of 88 technical papers, 15 popular articles, 46 consulting reports, 5 handbooks, 2 textbooks, and 4 patents.

JOHN REPLOGLE is currently a Research Hydraulic Engineer and Chief Scientist at the U.S. Water Conservation Laboratory in Phoenix. He received his B.S and M.S. in Agricultural Engineering, and his Ph.D. in Civil Engineering, from the University of Illinois.

Dr. Replogle's past work has included leading research related to crop water management and on-farm irrigation system performance, irrigation delivery systems and their impacts on farm operations, and hardware and management techniques to improve delivery system capabilities to deliver water in response to on-farm crop water needs (on-demand). At the Water Conservation Laboratory, he serves as Lead Scientist and Research Hydraulic Engineer for developing control schemes, flow measurements methods related to irrigation management, and technology transfer methods related to irrigation. His work in canal flow measuring methods has led to frequent travels to irrigated areas of the world including Bangladesh, Pakistan, Nepal, and India. Clients for this work have included USAID, USDA, United Nations Development, Education Development Center, Inc., and Winrock International. He has authored or co-authored over 100 technical papers, including several books, book chapters and related articles on irrigation and irrigation system flow measurement, control, and management.

During the past decade Dr. Replogle has earned the Hancor Soil and Water Engineering Award, the Hydraulics Structures Medal, and the Royce J Tipton Award "...for a distinguished record of accomplishments in the field of irrigation and drainage engineering through research and service." He is a member of the American Society of Agricultural Engineers, the American Society of Civil Engineers, the International Commission on Irrigation and Drainage, and the American Association for the Advancement of Science.

OTHER PARTICIPANTS

Panel deliberations were supported by three distinct groups: stakeholder technical advisors, stakeholder policy advisors, and an Authority-led technical team. Below is a brief description of each of these groups and a listing of primary participants.

Stakeholder Technical Advisors: Each primary stakeholder group (agriculture, environmental and agency) was invited to nominate technical representatives to help the Panel and Authority staff and consultants better understand local issues, conditions and information sources. Technical Advisors participated during the Panel deliberations and also provided guidance between meetings. Primary participants in this process included: Roger Reynolds with Summers Engineering; Joe Lima with Modesto Irrigation District; Mark Van Camp with MBK Engineering Lloyd Fryer with Kern County Water Agency; Dana Haasz with the Pacific Institute; Larry Farwell, independent consultant; Tracy Slavin with the U.S. Bureau of Reclamation; and various representatives from the California Departments of Water Resources and Food and Agriculture.

Stakeholder Policy Advisors: A CALFED-convened stakeholder group representing diverse agricultural, environmental and agency interests served as a sounding board throughout the process, providing input into Panel design, panelists selection and panel focus. Primary participants in this process have included Van Tenney, General Manager, Glenn-Colusa Irrigation District; Betsy Reifsnider, Executive Director, Friends of the River; Tracy Slavin with the U.S. Bureau of Reclamation; and various representatives from the California Departments of Water Resources and Food and Agriculture.

Authority Technical Team: CALFED Bay-Delta Authority staff and consultants, referred to as the Technical Team, provided extensive technical support for the Panel. The Technical Team's activities focused on managing the Panel process and undertaking the technical analysis. Key members of the team include: Tom Gohring, WUE Program Manager; Mark Roberson, independent consultant to CALFED; David Mitchell, resource economist with M-Cubed; Lee Axelrad with Resources Law Group; Kevin Johansen with Provost & Pritchard Engineering Group; and Scott McCreary and Bennett Brooks with CONCUR, Inc. David Purkey, a groundwater specialist formerly with West World Water, was involved in the earlier phases of the Panel's deliberations.

APPENDIX B:

WATER USE MEASUREMENT: CALIFORNIA LEGAL AUTHORITIES

SUMMARY

The purpose of this appendix is to present a summary of a compilation of the wide array of legal authorities pertaining to measurement of water use in California. This area of law is not a single, unified, statutory scheme, simply garnished with a few judicial decisions. Rather, the law affecting water use measurement in California derives from a variety of sources. This summary thus draws from provisions of the California Constitution, federal and state statutes and regulations, court decisions, agency guidance documents, intergovernmental memoranda of understanding and voluntary standards, technical standards issued by industry associations, and other authoritative sources of rules and standards pertaining to water use measurement. Some pieces of the measurement puzzle are explicitly linked, such as where a state statute incorporates a technical standard promulgated by a private association. Other pieces might seem unrelated, were it not for the fact that they all bear upon the measurement — and therefore the management — of one of California's most important natural and economic resources.

As set forth in greater detail in this section, water use measurement in California is associated not only with state law, but also with voluntary efforts and federal requirements. Particular areas of the California Water Code currently include provisions relating in various ways to the topic of measurement, which may suggest potential locations for grouping any future measurement-related provisions. The California Department of Water Resources and State Water Resources Control Board have certain existing authorities related to inquiries into or required statements and notices about current water use.

A number of counties have been identified in state statutes as meriting special attention due to concerns about groundwater. There, certain extractors subject to the requirement must report to the State Water Resources Control Board the quantities of water extracted from the ground as well as the quantities diverted from surface sources. Where a local agency voluntarily adopts a groundwater management plan, the agency may impose an annual fee to pay for implementation of the plan. The fee is to be based on the amount of groundwater extracted from the basin.

In connection with transfers or conjunctive use, depending on the particular mechanism used, the person sending the water may be required to demonstrate that their transfer would not injure another water user, which may be helped by a showing of prior consumptive use of the water proposed to be transferred. To protect their water rights, the person sending water also may be required in certain instances to file reports describing their reduction in water use, a description that would be facilitated by having documentation of previous and current use.

Below is a brief summary of the primary authorities pertaining to the measurement of water use in California. (A more detailed look at each of these authorities is included elsewhere in this section.)

APPENDIX B: WATER USE MEASUREMENT AUTHORITIES

POLICY OF THE AMERICAN WATER WORKS ASSOCIATION

- Recommends that every water utility meter all water taken into its system and all water distributed from it system to its users.

THE CALIFORNIA WATER USE MEASUREMENT LAW

- Legislature finds and declares that it is necessary to determine the quantities of water in use throughout the state to the maximum extent that is reasonable to do so, and that unmeasured water use causes waste and unreasonable use which should be identified, isolated, and eliminated.
- Sets state goal of installing meters on all new water service connections after January 1, 1992.
- Requires that domestic cold water meters comply with AWWA standards and be approved by State Director of Food and Agriculture.

WATER CODE SECTION 110

- Requires metering of all new potable water service starting January 1, 1992.

AUTHORITIES OF THE COUNTY SEALERS OF WEIGHTS AND MEASURES

- Shall inspect, try and test all instruments for measurements used by any proprietor, agent, lessee or employee for commercial purposes.

AUTHORITIES OF CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

- Division of Measurement Standards has general supervision of the weights and measures and weighing and measuring devices sold or used in the state.
- Adopts by regulation the latest standards of the National Conference on Weights and Measures, National Institute of Standards and Technology Handbook 44, including those applicable to devices for the measurement of water.

AUTHORITIES OF THE CALIFORNIA PUBLIC UTILITIES COMMISSION

- Regulates privately-owned utilities and some municipally-owned utilities.
- By statute, Legislature has defined "public utility" to include certain water corporations.
- CPUC jurisdiction only extends to public utilities where utility property has been dedicated to public use.
- Where CPUC has jurisdiction, it has very broad powers to supervise and regulate, and "may do all things… necessary and convenient in the exercise of such power and jurisdiction."
- Under the California Constitution, "A city, county, or other public body may not regulate matters over which the Legislature grants regulatory power to the Commission."
- Where CPUC has jurisdiction, it specifically may impose water measurement standards.
- CPUC General Order 103 sets minimum standards for water meters applicable to CPUC-regulated water corporations, requires measurement of water production, and requires volumetric sales except that flat rate or estimated service is allowed for temporary service, fire protection service, street and sewer service, or if authorization is first obtained from the CPUC.

URBAN WATER MANAGEMENT PLANNING

- Urban water suppliers shall adopt a water management plan, including descriptions of past and projected water use.
- DWR considers plan adoption and implementation when evaluating grant and loan applications.

MEMORANDUM OF UNDERSTANDING REGARDING EFFICIENT WATER MANAGEMENT PRACTICES FOR AGRICULTURAL WATER SUPPLIERS IN CALIFORNIA

- MOU signatories become members of Agricultural Water Management Council, and plan and implement cost-effective efficient water management practices, including water use measurement.

MEMORANDUM OF UNDERSTANDING REGARDING URBAN WATER CONSERVATION IN CALIFORNIA

- MOU signatories become members of California Urban Water Conservation Council and undertake a good faith effort to implement best management practices, including metering of all connections and volumetric billing.

BUREAU OF RECLAMATION CONTRACTS

- All Central Valley Project water service or repayment contracts shall ensure that all surface water delivery systems are equipped with water measuring devices or methods acceptable to the Secretary.
- Districts with certain types of Bureau contracts are required to submit water management plans, describing measurement devices and implementing BMPs deemed critical, including measuring agricultural deliveries to within a specified degree of accuracy and metering all new and existing urban connections.

APPENDIX B: WATER USE MEASUREMENT AUTHORITIES

WATER FORUM AGREEMENT

- MOU signatories in Sacramento region agree to implement certain actions, including CUWCC water conservation plans and BMPs, and specifically including residential retrofit of unmetered connections and conservation pricing.

AUTHORITIES OF BOTH STATE WATER RESOURCES CONTROL BOARD AND DEPARTMENT OF WATER RESOURCES

DWR and SWRCB "shall take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water...."

AUTHORITIES OF THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

- DWR may investigate water use, and is authorized to collect hydrologic data.
- DWR or any other public agency that supplies water for agricultural use may institute a water conservation program, including using, providing to farmers, or assisting farmers in the use of flow measuring devices.
- DWR shall update California Water Plan (Bulletin 160) every five years, and in doing so must release a preliminary draft that identifies assumptions and estimates relating to current and projected water use for urban and open space uses.

AUTHORITIES OF THE STATE WATER RESOURCES CONTROL BOARD

- Holders of riparian and pre-1914 appropriative rights must submit statements of water diversion and use every three years, indicating quantity of water used.
- Holders of permits for surface diversion or storage or underground storage may be required to establish suitable measuring and recording devices.
- After issuance of permits, a permittee must submit progress reports each year. After perfection of water right, a licensee must submit progress reports every three years specifying the amount of water taken.
- Persons extracting more than 25 acre-feet of groundwater per year in Riverside, San Bernardino, Los Angeles, and Ventura Counties must file a notice of extraction and diversion of water with SWRCB, stating quantity of water taken and method of measurement over preceding ten years, as to both groundwater and surface water taken.

MEASUREMENT IN WATERMASTER SERVICE AREAS

- Owners of conduits and certain reservoirs within watermaster service areas are required to construct and maintain such flow measuring devices as DWR may require, to assist the watermaster in determining the amounts being diverted and applied to beneficial use.

GROUNDWATER MANAGEMENT PROGRAMS UNDER THE GROUNDWATER MANAGEMENT ACT OF 1992 (A.B. 3030), AS AMENDED

- Any local agency can adopt a groundwater management plan, and may, after an election, impose fees and assessments based on amounts extracted.

GROUNDWATER MANAGEMENT DISTRICTS

- Several distinct statutes create separate groundwater management districts, typically empowering districts to require or engage in measurement of water use.

TRANSFERS AND CONJUNCTIVE USE

- Before allowing certain kinds of transfers, the SWRCB must review available records and find, among other things, that the change will not injure another user or unreasonably effect fish and wildlife, and, as with CVPIA transfers, must determine further if the water proposed to be transferred would have otherwise been consumptively used.
- In allowing a surplus water transfer involving conserved water, the SWRCB may require the user to file reports describing the amount of reduction of water use due to conservation efforts.
- In allowing pumping in lieu of using surface water, the SWRCB may require the user to file reports describing the amount of reduction of water use due to substitution of an alternate supply.
- Any user of imported or conserved surface water using the water in lieu of groundwater extraction shall file with the SWRCB an annual statement of the amount applied to reasonable beneficial use.

POLICY OF THE AMERICAN WATER WORKS ASSOCIATION

The board of directors of the American Water Works Association[1] has adopted the following policy statement:

> "The American Water Works Association (AWWA) recommends that every water utility meter all water taken into its system and all water distributed from its system to its users. Metering of all water services is an effective means of improving and maintaining the close control of water system operations necessitated by the increasing difficulty in obtaining adequate water supplies and the increasing costs of providing water service to consumers. Charging for water service on the basis of metered consumption provides a means of assessing users equitably for water service. Metering also provides a database for system performance studies and aids in the evaluation of conservation measures. It improves accountability for water delivered through the system and, therefore, facilitates management decisions. Continual and periodic testing of meters is an essential part of a universal metering program."[2]

THE CALIFORNIA WATER USE MEASUREMENT LAW

California's "Water Use Measurement Law" is found in California Water Code, division 1, chapter 8, sections 500 through 530. The Water Use Measurement Law was enacted as part of Senate Bill 229 (Boatwright), which was signed into law by the Governor in 1991.

LEGISLATIVE FINDINGS AND DECLARATIONS

In enacting the Water Use Measurement Law, the Legislature made the following findings and declarations:

Necessity of Measurement: "[I]t is necessary to determine the quantities of water in use throughout the state to the maximum extent that is reasonable to do so."[3]

Absence of Measurement Causes Waste and Unreasonable Use of Water: "[W]ater furnished or used without any method of determination of the quantities of water used by the person to whom the water is furnished has caused, and will continue to cause, waste and unreasonable use of water, and… this waste and unreasonable use should be identified, isolated, and eliminated."[4]

Waste and Unreasonable Use of Water Cause Waste of Energy: "[W]aste or unreasonable use of water imposes unnecessary and wasteful consumption of energy to deliver or furnish the water, and it is necessary, therefore, to determine the quantities of water in use throughout the state to the maximum extent that it is reasonable to do so in order to reduce that energy consumption."[5]

State Goal of Metering All New Water Service Connections Commencing in 1992: "[T]he California goal for measurement of water use is the achievement by January 1, 1992, of the installation of water meters on all new water service connections after that date to systems and facilities owned, operated, or under the management or control of a water purveyor, which meters will measure the quantity of water furnished or delivered through each system or facility to each new user of the water."[6] The Legislature gave inclusive definitions to the key terms of this goal statement, not expressly limiting its application to potable water.[7]

TECHNICAL STANDARDS

The Water Use Measurement Law also provides that "[d]omestic cold water meters shall be in compliance with relevant standards of the American Water Works Association and shall be of the type approved by the Director of Food and Agriculture pursuant to Section 12500.5 of the Business and Professions Code."[8]

1. "Founded in 1881, AWWA is the largest organization of water supply professionals in the world. Its more than 50,000 members represent the full spectrum of the drinking water community: treatment plant operators and managers, scientists, environmentalists, manufacturers, academicians, regulators, and others who hold genuine interest in water supply and public health. Membership includes more than 4,000 utilities that supply water to roughly 180 million people in North America." Website of the AWWA <www.awwa.org/about> visited January 13, 2002.
2. Adopted by the Board of Directors of the AWWA on Jan. 26, 1969, and revised on June 15, 1980, reprinted in American Water Works Association, 1982-83 Officers and Committee Directory, including Policy Statements and Official Documents
3. Cal. Water Code, § 520.
4. Cal. Water Code, § 521. Regarding waste and unreasonable use of water, the California Constitution provides: "It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water…." Cal. Constitution, Art. X, § 2.
5. Cal. Water Code, § 522.
6. Cal. Water Code, § 523.
7. "'Water meter' includes any suitable water measuring device or facility which measures or determines the volumetric flow of water." Cal. Water Code, § 516. "'Water service' means the sale, lease, rental, furnishing, or delivery of water for beneficial use, and includes, but is not limited to, contracting for that sale, lease, rental, furnishing, or delivery of water, except bottled water." Cal. Water Code, § 515. "'Water purveyor' means any person who furnishes water service to another person." Cal. Water Code, § 512. "'Person' means any individual, firm, association, partnership, corporation, or public entity of any kind." Cal. Water Code, § 513. "'Public entity' includes a city, county, city and county, whether general law or chartered, a district, board, commission, bureau, authority, agency, department, division, section, any other political subdivision of the state of any kind, or the state." Cal. Water Code, § 514.
8. Cal. Water Code, § 530. "The [Secretary of Food and Agriculture] by rules and regulations shall provide for submission for approval of types or designs of weights, measures, or weighing, measuring, or counting instruments or devices, used for commercial purposes, and shall issue certificates of approval of such types or designs as he shall find to meet the requirements of this code and the tolerances and specifications thereunder. [¶] It shall be unlawful to sell or use for commercial purposes any weight or measure, or any weighing, measuring, or counting instrument or device, of a type or design which has not first been so approved by the department; provided, however, that any such weight, measure, instrument, or device in use for commercial purposes prior to the effective date of this act may be continued in use unless and until condemned under the provisions of this code." Cal. Bus. & Professions Code, § 12500.5; see also Cal. Bus. & Professions Code, §§ 12500, subds. (b) & (e), 12500.9.

WATER CODE SECTION 110, REQUIRED METERING OF NEW POTABLE WATER SERVICE

In the same bill that enacted the Water Use Measurement Law, the Legislature also enacted a provision to require metering of new water service.[9] In setting forth this metering requirement, the Legislature used the same inclusive definitions it had used in the Water Measurement Law in regard to the metering goal. However, here, the Legislature expressly limited the metering requirement "only to potable water."[10]

> "Notwithstanding any other provision of law, every water purveyor who sells, leases, rents, furnishes, or delivers water service to any person shall require, as a condition of new water service on and after January 1, 1992, that a suitable water meter to measure the water service shall be installed on the water service facilities in accordance with Chapter 8 (commencing with Section 500). The cost of installation of the meter shall be paid by the user of the water, and any water purveyor may impose and collect charges for those costs."[11]

AUTHORITIES OF THE COUNTY SEALERS OF WEIGHTS AND MEASURES

State statute establishes "in each county the office of county sealer of weights and measures. The county sealer shall be appointed by the board of supervisors, except in chartered counties where a different method of appointment is prescribed."[12]

"Each sealer shall, within his or her county inspect, try and test all weights, scales, beams, measures of any kind, instruments or mechanical devices for weighing or measurements, and tools, appliances and accessories connected with any or all such instruments or measures, sold, or used by any proprietor, agent, lessee or employee for commercial purposes, as defined in subdivision (e) of Section 12500."[13]

"'Commercial purposes' include the determination of the weight, measure, or count of any commodity or thing which is sold on the basis of weight, measure, or count; or the determination of the weight, measure, or count of any commodity or thing upon which determination a charge for service is based. Devices used in a determination upon which a charge for service is based include, but are not limited to, taximeters, odometers, timing devices, parcel scales, shipping scales, and scales used in the payment of agricultural workers. 'Commercial purposes' do not include the determination of the weight, measure, or count of any commodity or thing which is performed within a plant or business as a part of the manufacturing, processing, or preparing for market of that commodity or thing, or the determination of charges for the transmission of letters or parcels of less than 150 pounds, except when that determination is made in the presence of the customer charged for the service."[14]

AUTHORITIES OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

"Where not otherwise provided by law, the Department of Food and Agriculture has general supervision of the weights and measures and weighing and measuring devices sold or used in the state."[15] The Department carries out this duty through its Division of Measurement Standards.

"The [Secretary of Food and Agriculture] by rules and regulations shall provide for submission for approval of types or designs of weights, measures, or weighing, measuring, or counting instruments or devices, used for commercial purposes, and shall issue certificates of approval of such types or designs as he shall find to meet the requirements of this code and the tolerances and specifications thereunder. It shall be unlawful to sell or use for commercial purposes any weight or measure, or any weighing, measuring, or counting instrument or device, of a type or design which has not first been so approved by the department; provided, however, that any such weight, measure, instrument, or device in use for commercial purposes prior to the effective date of this act may be continued in use unless and until condemned under the provisions of this code."[16]

"Notwithstanding Section 12500.5, the [Secretary of Food and Agriculture] may prohibit the sale or installation of any previously approved type or design of weight or measure or weighing, measuring, or counting instrument if the director determines the weight, measure, or instrument does not fulfill the purpose for which it was approved or that the weight, measure, or instrument is not identical to the approved type or design. The director may initiate proceedings pursuant to Chapter 5 (commencing with Section 11500) of Part 1 of Division 3 of Title 2 of the Government Code to determine whether the approval should be revoked or modified, and to determine the period of time that the owner or user of any accurate device for which type approval has been revoked or modified may continue to use that device for commercial purposes, pending the replacement or modification of the device."[17]

"The [Secretary of Food and Agriculture] shall establish tolerances and specifications and other technical requirements for commercial weighing and measuring. In doing so,

9. Cal. Water Code, § 110.
10. Cal. Water Code, § 110, subds. (b) & (c). The Legislature also said that the metering requirement "does not apply to a community water system which serves less than 15 service connections used by yearlong residents or regularly serves less than 25 yearlong residents, or a single well which services the water supply of a single family residential home." Cal. Water Code, § 110, subd. (d).
11. Cal. Water Code, § 110, subd. (a).
12. Cal. Business & Professions Code, § 12200.
13. Cal. Business & Professions Code, § 12210.
14. Cal. Business & Professions Code, § 12500, subd. (e).
15. Cal. Business & Professions Code, § 12100.
16. Cal. Business & Professions Code, § 12500.5.
17. Cal. Business & Professions Code, §12500.6.

the [Secretary of Food and Agriculture] shall adopt, by reference, the latest standards as recommended by the National Conference on Weights and Measures and published in the National Institute of Standards and Technology Handbook 44 "Specifications and Tolerances, and other Technical Requirements for Weighing and Measuring Devices," except as specifically modified, amended, or rejected by regulation adopted by the [Secretary of Food and Agriculture]. The [Secretary of Food and Agriculture] may, by regulation, establish tolerances and specifications for commercial weighing and measuring devices not included in Handbook 44… It shall be unlawful for any person to violate any of the rules, regulations, tolerances, specifications, or standards established under this section."[18]

The detailed technical requirements adopted by the Secretary of Food and Agriculture, incorporating the standards of the National Conference on Weights and Measures, apply "to devices used for the measurement of water; generally applicable to, but not limited to, utilities type meters installed in homes or business establishments and meters installed in batching systems."[19]

AUTHORITIES OF THE CALIFORNIA PUBLIC UTILITIES COMMISSION

JURISDICTION OF CALIFORNIA PUBLIC UTILITIES COMMISSION

The California Public Utilities Commission (CPUC) has power to regulate only privately-owned utilities, unless an express statutory provision authorizes CPUC jurisdiction over municipally-owned utilities.[20]

The California Constitution directly gives the CPUC power to regulate certain activities (e.g., transportation companies). "Furnishing water to the public," however, is an activity that the Constitution entrusts to the control of the Legislature. "Private corporations and persons that own, operate, control, or manage a… system for… furnishing… water… directly or indirectly to or for the public… are public utilities subject to control by the Legislature. The Legislature may prescribe that additional classes of private corporations or other persons are public utilities."[21] However, the Constitution further provides that "[t]he Legislature has plenary power, unlimited by the other provisions of this constitution but consistent with this article, to confer additional authority and jurisdiction upon the [CPUC]… "[22] Thus, the CPUC's power to regulate water corporations as public utilities relies on a legislative grant of authority to the CPUC.

By statute, the Legislature has defined what constitutes a "public utility" subject to CPUC jurisdiction.

- "'Public utility' includes every… water corporation[23]… where the service is performed for, or the commodity is delivered to, the public or any portion thereof.
- "Whenever any… water corporation… performs a service for, or delivers a commodity to, the public or any portion thereof for which any compensation or payment whatsoever is received, that… water corporation… is a public utility subject to the jurisdiction, control, and regulation of the commission and the provisions of this part.
- "When any person or corporation[24] performs any service for, or delivers any commodity to, any person, private corporation, municipality, or other political subdivision of the state, that in turn either directly or indirectly, mediately or immediately, performs that service for, or delivers that commodity to, the public or any portion thereof, that person or corporation is a public utility subject to the jurisdiction, control, and regulation of the commission and the provisions of this part."[25]

Additional specific meanings of "public utility" as that term is applied to "water companies" are also defined by statute. Public utilities subject to CPUC jurisdiction, thus, include:

- "Any person, firm, or corporation, their lessees, trustees, receivers or trustees appointed by any court whatsoever, owning, controlling, operating, or managing any water system within this State, who sells, leases, rents, or delivers water to any person, firm, corporation, municipality, or any other political subdivision of the State, whether under contract or otherwise…"[26]
- "Any corporation or association which is organized for the purpose of delivering water solely to its stockholders or members at cost, and which delivers water to others than its stockholders or members, or to the state or any department or agency thereof or any school district, or to any other mutual water company, for compensation…"[27]

18. Cal. Business & Professions Code, § 12107.
19. Division of Measurement Standards, Dept. of Food and Agriculture, Field Reference Manual, § 3.36.A.1; see also Cal. Code Regs., tit. 4, div. 9, § 4002.6. These detailed standards can be found on the Internet at <http://www.cdfa.ca.gov/dms/regulations.htm> (visited January 16, 2003).
20. Witkin, 8 Summary of California Law, 9th Edition, Constitutional Law § 92, p. 436.
21. Cal. Const., art. XII, § 3.
22. Cal. Const., art. XII, § 5.
23. The applicable statutory definition of "water corporation" is "every corporation or person owning, controlling, operating, or managing any water system for compensation within this State." Cal. Pub. Utilities Code, § 241.
24. The applicable statutory definition of "corporation" is "a corporation, a company, an association, and a joint stock association." Cal. Pub. Utilities Code, § 204. This definition does not include a "municipal corporation." Order Instituting Investigation on the Commission's own motion into the rates, charges, and practices of water and sewer utilities providing service to mobilehome parks and multiple unit residential complexes and the circumstances under which those rates and charges can be passed on to the end user, California Public Utilities Commission Decision No. 01-05-058, 209 P.U.R. 4th 497 (May 14, 2001).
25. Cal. Pub. Utilities Code, § 216, subds. (a), (b), and (c).
26. Cal. Pub. Utilities Code, § 2701.
27. Cal. Pub. Utilities Code, § 2702.

- "Any corporation or association which is organized both for the purpose of delivering water to its stockholders or members at cost, and to persons, firms, corporations, municipalities, or other political subdivisions of the state..."[28]

However, by statutory exception to the above, water companies that are *not* subject to CPUC jurisdiction include:

- "Any owner of a water supply not otherwise dedicated to public use and primarily used for domestic or industrial purposes by him or for the irrigation of his lands, who (a) sells or delivers the surplus of such water for domestic or school district purposes or for the irrigation of adjoining lands, or (b) in an emergency water shortage sells or delivers water from such supply to others for a limited period not to exceed one irrigation season, or (c) sells or delivers a portion of such water supply as a matter of accommodation to neighbors to whom no other supply of water for domestic or irrigation purposes is equally available..."[29]
- "Any corporation or association that is organized for the purposes of delivering water to its stockholders and members at cost, including use of works for conserving, treating, and reclaiming water, and that delivers water to no one except its stockholders or members, or to the state or any agency or department thereof, to any city, county, school district, or other public district, or any federal agency that provides fire protection or operates park facilities, or to any other mutual water company, at cost..."[30]
- "Any person or corporation, and their lessees, receivers, or trustees appointed by any court, that maintains a mobilehome park or a multiple unit residential complex and provides, or will provide, water service to users through a submeter service system,... if each user of the submeter service system is charged at the rate which would be applicable if the user were receiving the water directly from the water corporation.[31]
- "A mobilehome park that provides water service only to its tenants from water supplies and facilities that it owns, not otherwise dedicated to public service..."[32]
- Other than mutual water companies, "[a]ny person, firm, or corporation, their lessees, trustees, receivers or trustees appointed by any court, who sells or delivers water exclusively to a water conservation district organized under the laws of the state or who leases or otherwise permits the use of ditches or other water transmission facilities exclusively by the district..."[33]
- Other than mutual water companies, "[a]ny person, firm, or corporation with water that is not being used to supply water to a public water system, or that is not otherwise dedicated to public use, that sells, leases, transfers, or otherwise delivers the water at wholesale to any public agency or to a water corporation providing water utility service."[34]
- "[D]uring the time the United States is a party to war or to a state of war, the owner of any private irrigation plant [delivering] water to others, or any mutual water company [delivering] water to others than its stockholders or members, with or without compensation."[35]

In addition to the above statutory requirements for an entity to be considered a public utility subject to CPUC jurisdiction, there is also a requirement, articulated in court cases, that, notwithstanding satisfaction of the statutory definition, an entity is not a public utility unless utility property has expressly or impliedly been *dedicated to public use*. Specifically, an act of "dedication" occurs if an entity:

> "held himself out, expressly or impliedly, as engaged in the business of supplying [a service or commodity] to the public as a class, not necessarily to all of the public, but to any limited portion of it, such portion, for example, as could be served by his own system, as counterdistinguished from his holding himself out as serving or ready to serve only particular individuals, either as a matter of accommodation or for other reasons peculiar and particular to them."[36]

28. Cal. Pub. Utilities Code, § 2703.
29. Cal. Pub. Utilities Code, § 2704.
30. Cal. Pub. Utilities Code, § 2705. In addition, "a mutual water company may perform the following acts without becoming a public utility and becoming subject to the jurisdiction, control or regulation of the commission: (a) May deliver water at cost to any lessee of its stock or shares or other evidence of membership where the lease is in writing signed by the owner of the stock or shares or other evidence of membership and the lessee thereof and approved by the mutual water company. (b) May deliver water at cost to any land leased by a stockholder, shareholder, or member of the mutual water company to a person not a stockholder, shareholder or member thereof, provided the lease is in writing signed by the stockholder, shareholder or member and the lessee of the land and approved by the mutual water company. (c) May transfer water or water rights to, or exchange water or water rights with, another entity pursuant to state or federal law, or both. (d) In a bona fide water emergency, but for no longer than the existence of the emergency, may deliver water at cost to any person owning or leasing real property located within or adjacent to the service area of the mutual water company, provided that the water is delivered pursuant to a written contract signed by the mutual water company and the person to whom the water is delivered. (e) May deliver water pursuant to any contract for water service made: (1) In settlement of litigation involving disputed water rights or any judgment in the litigation. (2) In consideration of the conveyance of a well, water right, or easement for water distribution purposes." Id.
31. Cal. Pub. Utilities Code, § 2705.5.
32. Cal. Pub. Utilities Code, § 2705.6.
33. Cal. Pub. Utilities Code, § 2706, subds. (a) & (c).
34. Cal. Pub. Utilities Code, § 2706, subds. (b) & (c).
35. Cal. Pub. Utilities Code, § 2727.
36. *Van Hoosear v. Railroad Commission* (1920) 184 Cal. 553, 554, quoted in California Public Utilities Commission Decision No. 01-05-058, 209 P.U.R. 4th 497 (May 14, 2001).

"Whether or not dedication has occurred is a factual question."[37] Moreover, dedication "may be inferred from the acts of the owner and his dealings in relations to the property."[38] Thus, the CPUC must examine the question of dedication on a case-by-case basis.[39]

POWERS AND REQUIREMENTS WHERE CPUC JURISDICTION APPLIES

General Powers

Where it has jurisdiction, the CPUC also has very broad powers. "The commission may supervise and regulate every public utility in the State and may do all things, whether specifically designated in [the Public Utilities Act] or in addition thereto, which are necessary and convenient in the exercise of such power and jurisdiction."[40] "Every public utility shall obey and comply with every order, decision, direction, or rule made or prescribed by the commission in the matters specified in this part, or any other matter in any way relating to or affecting its business as a public utility, and shall do everything necessary or proper to secure compliance therewith by all of its officers, agents, and employees."[41] "The commission may fix rates, establish rules, examine records, issue subpoenas, administer oaths, take testimony, punish for contempt, and prescribe a uniform system of accounts for all public utilities subject to its jurisdiction."[42]

Powers Relating to Practices, Equipment, Appliances, Facilities and Methods

"Whenever the commission, after a hearing, finds that the rules, practices, equipment, appliances, facilities, or service of any public utility, or the methods of manufacture, distribution, transmission, storage, or supply employed by it, are unjust, unreasonable, unsafe, improper, inadequate, or insufficient, the commission shall determine and, by order or rule, fix the rules, practices, equipment, appliances, facilities, service, or methods to be observed, furnished, constructed, enforced, or employed. The commission shall prescribe rules for the performance of any service or the furnishing of any commodity of the character furnished or supplied by any public utility, and, on proper demand and tender of rates, such public utility shall furnish such commodity or render such service within the time and upon the conditions provided in such rules."[43]

Powers Relating to Measurement

"The commission may after hearing: (a) Ascertain and fix just and reasonable standards, classifications, regulations, practices, measurements, or service to be furnished, imposed, observed, and followed by all... water... corporations. (b) Ascertain and fix adequate and serviceable standards for the measurement of quantity, quality, pressure, or other condition pertaining to the supply of the product, commodity, or service furnished or rendered by any such public utility. No standard of the commission applicable to any water corporation shall be inconsistent with the regulations and standards of the State Department of Health pursuant to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code. (c) Prescribe reasonable regulations for the examination and testing of the product, commodity, or service and for the measurement thereof. (d) Establish reasonable rules, specifications, and standards to secure the accuracy of all meters and appliances for measurements. The commission shall require a public utility that estimates meter readings to so indicate on its billings, and shall require any estimate that is incorrect to be corrected by the next billing period, except that for reasons beyond its control due to weather, or in cases of unusual conditions, corrections for any overestimate or underestimate shall be reflected on the first regularly scheduled bill and based on an actual reading following the period of inaccessibility. (e) Provide for the examination and testing of any and all appliances used for the measurement of any product, commodity, or service of any such public utility.[44]

Established Water Meter Standards: General Order 103

In 1956, the CPUC first adopted General Order 103, which sets the minimum standards for water meters applicable to CPUC-regulated water corporations.[45] The rules set forth in General Order 103 "are designed primarily for utility systems supplying potable water under pressure but shall apply insofar as they may be appropriate to utility systems supplying water not intended or claimed to be potable from ditches, canals or other conduits."[46]

Pursuant to General Order 103, "[e]ach utility shall install a suitable measuring device, or otherwise determine production, at each source of supply in order that a record may be maintained of the quantity of water produced by each source."[47] "At least once each month, the quantity produced from each source of supply shall be determined. Twelve month totals by sources shall be recorded and transmitted to the Commission in the utility's annual report to the Commission."[48]

37. California Public Utilities Commission Decision No. 01-05-058, 209 P.U.R. 4th 497 (May 14, 2001), citing *Haynes v. MacFarlane* (1929) 207 Cal. 529, 532.
38. Cal. Water & Tel. Co. v. Public Util. Com. (1959) 51 Cal.2d 476, 494, quoted in California Public Utilities Commission Decision No. 01-05-058, 209 P.U.R. 4th 497 (May 14, 2001).
39. California Public Utilities Commission Decision No. 01-05-058, 209 P.U.R. 4th 497 (May 14, 2001).
40. Cal. Pub. Utilities Code, § 701.
41. Cal. Pub. Utilities Code, § 702.
42. Cal. Const., art. XII, § 6.
43. Cal. Pub. Utilities Code, § 761.
44. Cal. Pub. Utilities Code, § 770.
45. California Public Utilities Commission, General Order 103, Rules Governing Water Service Including Minimum Standards for Design and Construction (as amended March 9, 1994), § I.1.a.
46. General Order 103, § I.2.
47. General Order 103, § II.4.a.
48. General Order 103, § II.4.b.

"All water sold by a utility shall be on the basis of metered volume sales except that the utility may at its option provide flat rate or estimated service for the following: (1) Residential, business, commercial, industrial (in special situations) and irrigation service after authorization has first been obtained from the Commission; (2) Temporary service where the water use can be readily estimated; (3) Public and private fire protection service; (4) Water used for street sprinkling and sewer flushing, when provided for by contract between the utility and the municipality or other local governmental authority."[49]

"All meters used for metered sales excluding sales from irrigation systems or other irrigation sales shall have registration devices indicating the volume of water in either cubic feet or United States gallons."[50] "Irrigation service may be provided with meters which measure in acre feet or miner's inch days. This service may also be rendered on a volume basis by the use of a calibrated orifice such as the miner's inch box, by the use of weirs or otherwise measured as provided in applicable tariff schedules."[51]

General Order 103 also contains a variety of other detailed requirements, including a set of requirements pertaining to utility-provided meter test facilities and equipment,[52] accuracy requirements,[53] and others.

Non-Interference With CPUC Jurisdiction

Where the CPUC has jurisdiction, it generally has not only broad powers, but also broad latitude to exercise those powers either to the exclusion of other governmental agencies, or, occasionally, in parallel with other agencies.

"A city, county, or other public body may not regulate matters over which the Legislature grants regulatory power to the Commission. This section does not affect power over public utilities relating to the making and enforcement of police, sanitary, and other regulations concerning municipal affairs pursuant to a city charter existing on October 10, 1911, unless that power has been revoked by the city's electors, or the right of any city to grant franchises for public utilities or other businesses on terms, conditions, and in the manner prescribed by law."[54]

49. General Order 103, § VI.1.a.
50. General Order 103, § VI.1.b.
51. General Order 103, § VI.1.c.
52. General Order 103, § VI.2 (b (pursuant to General Order 103, appen. A, the requirements of section VI, subdivision 2 are not applicable "when sales are measured by other than displacement meters as provided in applicable tariff schedules").
53. General Order 103, § VI.3. "All meters used for measuring quantities of water delivered to customers shall be in good mechanical condition, shall be adequate in size and design for the type of service which each measures and shall be accurate to within generally accepted standards." § VI.3.a. "For determination of minimum test flow and normal test flow limits, the Commission adopts as a guide the appropriate standard specifications of the American Water Works Association for the various types of meters." § VI.3.b (pursuant to General Order 103, appen. A, the requirements of section VI, subdivision 3.b. are not applicable "when sales are measured by other than displacement meters as provided in applicable tariff schedules").
54. Cal. Const., art. XII, § 8.

"No court of this state, except the Supreme Court and the court of appeal, to the extent specified in this article, shall have jurisdiction to review, reverse, correct, or annul any order or decision of the [CPUC] or to suspend or delay the execution or operation thereof, or to enjoin, restrain, or interfere with the commission in the performance of its official duties, as provided by law and the rules of court."[55]

Notwithstanding the fact that the Legislature has vested in the Department of Health Services primary responsibility for administration of the safe drinking water laws, including the California Safe Drinking Water Act,[56] for regulated public utilities the CPUC has authority to regulate and enforce water quality safety and limited authority to adopt water quality standards.[57]

URBAN WATER MANAGEMENT PLANNING

POLICY AND PURPOSE

In 1983, the Legislature enacted the "Urban Water Management Planning Act."[58] In doing so, the Legislature found and declared that it is the policy of the state that:

- "The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources."
- "The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions."
- "Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies."[59]

URBAN WATER SUPPLIERS

Under the Act, "urban water supplier" means "a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers."[60] The Act applies only to water supplied from public water systems subject to the California Safe Drinking Water Act.[61]

CONTENTS OF PLANS

Pursuant to the Act, a plan shall be adopted and implemented[62] and shall do several things, including the following which relate to measurement:

55. Cal. Pub. Utilities Code, § 1759, subd. (a).
56. Cal. Health & Safety Code, § 116325.
57. *Hartwell Corp. v. Superior Court (Santamaria)*(2002) 27 Cal.4th 256.
58. Cal. Water Code, § 10610, et seq.
59. Cal. Water Code, § 10610.4.
60. Cal. Water Code, § 10617.
61. Cal. Water Code, § 10617; Cal. Health & Safety Code, § 116270, et seq.
62. Cal. Water Code, § 10643.

- Include, if groundwater is identified as an existing or planned source of water available to the supplier:
  - — A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.
  - — A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

- Quantify, to the extent records are available, past and current water use (in five-year increments to 20 years or as far as data is available), and projected water use, identifying the uses among water use sectors including, but not necessarily limited to, all of the following uses:
  - — Single-family residential.
  - — Multifamily.
  - — Commercial.
  - — Industrial.
  - — Institutional and governmental.
  - — Landscape.
  - — Sales to other agencies.
  - — Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.
  - — Agricultural.

- Provide a description of the supplier's water demand management measures. This description shall include all of the following:
  - — A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:
    - > Metering with commodity rates for all new connections and retrofit of existing connections.
    - > System water audits, leak detection, and repair.
    - > Conservation pricing.
    - > [others]
  - — A schedule of implementation for all water demand management measures proposed or described in the plan.
  - — A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.
  - — An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

- Provide an evaluation of each listed water demand management measure that is not currently being implemented or scheduled for implementation.

- Urban water suppliers that are members of the California Urban Water Conservation Council and submit annual reports to that council in accordance with the "Memorandum of Understanding Regarding Urban Water Conservation in California," may submit the annual reports identifying water demand management measures currently being implemented, or scheduled for implementation, to satisfy the requirements (described above) relating to a description of the supplier's water demand management measures an evaluation of each listed water demand management measure that is not currently being implemented or scheduled for implementation.[63]

- The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The plan shall include all of the following:
  - — A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.
  - — A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.
  - — A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.
  - — A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge,

63. Cal. Water Code, § 10631.

and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

— The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

— A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

— A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.[64]

RATES

"An urban water supplier may recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan. Any best water management practice that is included in the plan that is identified in the 'Memorandum of Understanding Regarding Urban Water Conservation in California' is deemed to be reasonable for the purposes of this section."[65]

GRANTS AND LOANS

Pursuant to the Act, the Department of Water Resources shall take into consideration whether the urban water supplier is implementing or scheduled for implementation, the water demand management activities that the urban water supplier identified in its urban water management plan, in evaluating applications for grants and loans to fund urban water conservation projects made available pursuant to the Urban Water Conservation Program under California Water Code, section 79163. The urban water supplier may submit to the department copies of its annual reports and other relevant documents to assist the department in determining whether the urban water supplier is implementing or scheduling the implementation of water demand management activities.[66]

An urban water supplier that does not prepare, adopt, and submit its urban water management plan to the department in accordance with the Act, is ineligible to receive funding pursuant to the Safe, Clean, Reliable, Water Supply Act[67] or the Costa-Machado Water Act of 2000,[68] or to receive drought assistance from the state until the urban water management plan is properly submitted.[69]

The Department of Water Resources shall take into consideration whether the urban water supplier has submitted an updated urban water management plan that is consistent with the Act, in determining whether the urban water supplier is eligible for funds made available pursuant to any program administered by the department.[70]

WATER MANAGEMENT OR CONSERVATION PLANS REQUIRED BY OTHER STATE LAW INCLUDING PUBLIC UTILITIES COMMISSION AND STATE WATER RESOURCES CONTROL BOARD

"The adoption of [an Urban Water Management Plan pursuant to the Urban Water Management Planning Act] shall satisfy any requirements of state law, regulation, or order, including those of the State Water Resources Control Board and the Public Utilities Commission, for the preparation of water management plans or conservation plans; provided, that if the State Water Resources Control Board or the Public Utilities Commission requires additional information concerning water conservation to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan prepared to meet federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part."[71]

MEMORANDUM OF UNDERSTANDING REGARDING EFFICIENT WATER MANAGEMENT PRACTICES FOR AGRICULTURAL WATER SUPPLIERS IN CALIFORNIA

A multi-stakeholder Advisory Committee established pursuant to the California Agricultural Water Suppliers Efficient Water Management Practices Act of 1990, Assembly Bill 3616,[72] has developed a "Memorandum of Understanding Regarding Efficient Water Management Practices for Agricultural Water Suppliers in California" ("MOU"). In signing the MOU, signatories become members of the Agricultural Water Management Council ("AWMC"). Signatories include approximately thirty water districts, as well as environmental groups and other interested parties. Under the MOU, signatories will evaluate and

64. Cal. Water Code, § 10633.
65. Cal. Water Code, § 10654.
66. Cal. Water Code, § 10631.5.
67. Cal. Water Code, § 78500, et seq.
68. Cal. Water Code, § 79000, et seq.
69. Cal. Water Code, § 10656.
70. Cal. Water Code, § 10657. Pursuant to subdivision (b), section 10657 shall remain in effect only until January 1, 2006, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2006, deletes or extends that date.
71. Cal. Water Code, § 10653.
72. Stats 1990, ch. 739, § 1 (AB 3616).

endorse Water Management Plans. The MOU also provides a mechanism for signatories to plan and implement cost-effective Efficient Water Management Practices ("EWMPs").

The MOU sets forth lists of EWMPs in three categories. "List A" practices are "Generally Applicable Efficient Water Management Practices." "List B" practices are "Conditionally Applicable Efficient Water Management Practices." "List C" practices are "Other Efficient Water Management Practices." Each Water Management Plan will include all EWMPs from List A. Each Water Management Plan will contain all EWMPs from List B that are found to "generate net water management benefits." Each Water Management Plan will contain all EWMPs from List C "in the form(s) found to optimize net water management benefits".

One of the List C practices relates to water measurement and reporting. Under this practice:

- "A water supplier will measure or calculate the volume of water delivered within a reasonable range of accuracy. Such measurement or calculation will be by individual water user or other reasonable measurement/calculation option. A water supplier will provide timely water use reports to water users through billings or advisories."[73]

MEMORANDUM OF UNDERSTANDING REGARDING URBAN WATER CONSERVATION IN CALIFORNIA

The Memorandum of Understanding Regarding Urban Water Conservation in California ("MOU") was first executed with an initial effective date in 1991, and has since been amended several times. The MOU signatories represent urban water suppliers, public advocacy organizations and other interest groups, and collectively constitute the "California Urban Water Conservation Council" ("CUWCC").

The MOU applies only to the delivery of water for "domestic, municipal and industrial uses," and does not apply "directly or indirectly" to the use of water for irrigated agriculture. According to its own terms, the MOU "is intended to embody general principles agreed upon between and among the signatories and is not intended to create contractual relationships, rights, obligations, duties or remedies in a court of law between or among the signatories."

The MOU defines a set of "best management practices" and requires of all signatory water suppliers "a good faith effort" to implement each BMP. The MOU provides that a signatory water supplier will be exempt from the implementation of a specific BMP as long as the supplier substantiates at least one of the following: (a) the BMP would not be "cost effective"; (b) adequate funds to implement the practice "are not and cannot reasonably be made available"; or (c) implementation of the BMP is outside the supplier's legal authority, the supplier made "a good faith to work with" entities that have such authority others to carry out and remove barriers to the BMP. In addition to exemptions, the MOU also provides for delayed implementation if a supplier can first make certain findings.

BMP Number 4, under the MOU, applies to "metering with commodity rates for all new connections and retrofit of existing connections." It provides as follows:

A. Implementation. Implementation shall consist of at least the following actions:
   - Requiring meters for all new connections and billing by volume of use.
   - Establishing a program for retrofitting existing unmetered connections and billing by volume of use.
   - Identifying intra- and inter-agency disincentives or barriers to retrofitting mixed use commercial accounts with dedicated landscape meters, and conducting a feasibility study to assess the merits of a program to provide incentives to switch mixed use accounts to dedicated landscape meters.

B. Implementation Schedule
   a. Agencies signing the MOU prior to December 31, 1997, implementation shall commence no later than July 1, 1999.
   b. Agencies signing the MOU or becoming subject to the MOU after December 31, 1997, implementation shall commence no later than July 1 of the second year following the year the agency signed or became subject to the MOU.
   c. A plan to retrofit and bill by volume of use existing unmetered connections to be completed by the end of the first reporting period following the date implementation was to commence.
   d. A feasibility study examining incentive programs to move landscape water uses on mixed-use meters to dedicated landscape meters to be completed by end of the first reporting period following the date implementation was to commence.

C. Coverage Requirements
   100% of existing unmetered accounts to be metered and billed by volume of use within 10 years of date implementation was to commence.

D. Requirements for Documenting BMP Implementation
   a. Confirmation that all new connections are metered and are being billed by volume of use.

73. Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California (November 13, 1996), Ex. A, List C(1).

b. Number of unmetered accounts in the service area. For the purposes of evaluation, this shall be defined as the baseline meter retrofit target, and shall be used to calculate the agency's minimum annual retrofit requirement.
c. Number of unmetered connections retrofitted during the reporting period.
d. Number of CII accounts with mixed-use meters.
e. Number of CII accounts with mixed-use meters retrofitted with dedicated irrigation meters during reporting period.

E. Criteria to Determine BMP Implementation Status
a. Agency with existing unmetered connections has completed a meter retrofit plan by end of first reporting period following the date implementation was to commence.
b. Agency has completed a feasibility study examining incentive programs to move landscape water uses on mixed-use meters to dedicated landscape meters by end of first reporting period following the date implementation was to commence.
c. Agency with existing unmetered connections is on track to meter these connections within 10 years of the date implementation was to commence. An agency will be considered on track if the percent of unmetered accounts retrofitted with meters equals or exceeds the following: 10% by end of first reporting period following date implementation to commence; 24% by end of second reporting period; 42% by end of third reporting period; 64% by end of fourth reporting period; and 90% by end of fifth reporting period.

F. Water Savings Assumptions
Assume meter retrofits will result in a 20% reduction in demand by retrofitted accounts.

BUREAU OF RECLAMATION CONTRACTS

STANDARD CONTRACTUAL PROVISIONS

Under federal law, Central Valley Project ("CVP") contracts must include requirements for the employment of water measuring devices or methods.

> "All Central Valley Project water service or repayment contracts for agricultural, municipal, or industrial purposes that are entered into, renewed, or amended under any provision of Federal Reclamation Law after the date of enactment of this title, shall provide that the contracting district or agency shall ensure that all surface water delivery systems within its boundaries are equipped with water measuring devices or water measuring methods of comparable effectiveness acceptable to the Secretary within five years of the date of contract execution, amendment, or renewal, and that any new surface water deliveries systems installed within its boundaries on or after the date of contract renewal are so equipped."[74]

REPORTING OF DELIVERIES

Federal CVP contractors are also required to report water deliveries, not only to the federal government but also to the State of California.

> "The contracting district or agency shall inform the Secretary and the State of California annually as to the monthly volume of surface water delivered within its boundaries."[75]

CRITERIA FOR EVALUATING WATER MANAGEMENT PLANS

Pursuant to section 210 of the Reclamation Reform Act of 1982, districts with certain types of Bureau of Reclamation contracts are required to prepare and submit Water Management Plans to the Bureau.

> "Each district that has entered into a repayment contract or water service contract pursuant to Federal reclamation law or the Water Supply Act of 1958, as amended[76] shall develop a water conservation plan which shall contain definite goals, appropriate water conservation measures, and a time schedule for meeting the water conservation objectives."[77]

Pursuant to the Central Valley Project Improvement Act ("CVPIA"), the Bureau of Reclamation

> "shall establish and administer an office on Central Valley Project water conservation best management practices that shall, in consultation with the Secretary of Agriculture, the California Department of Water Resources, California academic institutions, and Central Valley Project water users, develop criteria for evaluating the adequacy of all water conservation plans developed by project contractors, including those plans required by section 210 of the Reclamation Reform Act of 1982."[78]

In 1996, the Bureau of Reclamation issued in final form an agency guidance document entitled "Criteria for Evaluat-

74. Central Valley Project Improvement Act (CVPIA), Pub. L. 102-575, title XXXIV, § 3405(b), Oct. 30 , 1992, 106 Stat. 4706.
75. Id.
76. 43 U.S.C. § 390b.
77. Reclamation Reform Act of 1982, 43 U.S.C. § 390jj(b).
78. CVPIA § 3405(e).

ing Water Management Plans."[79] The Bureau of Reclamation subsequently issued revised draft criteria in 1999[80] and 2002.[81] The Bureau of Reclamation makes these criteria applicable "to water management plans submitted to Reclamation as required by applicable Central Valley Project water delivery contract or any contract that specifically invokes these criteria."[82]

The 1996 criteria, and the subsequent revisions in 1999 and 2002, include a requirement that Water Management Plans shall describe..."customer water delivery measurements."[83] Plans are also supposed to describe, among other things, the District's incoming flow measurement method and locations."[84]

An adequate plan is also expected to

> "List the total number of customers/connections/turnouts, the number currently measured and the percentage of customer water deliveries measured. List the types and numbers of measurement devices (e.g., meters, calibrated gates, weirs, etc.), level of accuracy, frequency of calibration, and maintenance and reading schedule."[85]

Plans are also required to inventory water resources, including developing a water inventory for the contractor based on one of the last two years prior to preparation of each plan.[86] This inventory includes quantifying both water supplies and water used, in a detailed fashion.[87]

Contractors subject to the criteria are required to develop a program for implementation of certain best management practices ("BMPs"). Separate BMPs are identified for agricultural contractors and urban contractors.

79. U.S. Bureau of Reclamation, Mid-Pacific Region, Final Criteria for Evaluating Water Management Plans (Aug. 1996) ["1996 Criteria"].
80. U.S. Bureau of Reclamation, Mid-Pacific Region, Criteria for Evaluating Water Management Plans (1999) ["1999 Draft Criteria"].
81. U.S. Bureau of Reclamation, Mid-Pacific Region, Standard Criteria for Evaluating Water Management Plans (Draft June 20, 2002) ["2002 Draft Criteria"],
82. 2002 Draft Criteria, at p. 1. The following are excepted from the requirement to prepare a water management plan using these criteria: (1) all contractors that receive only irrigation water from any federal reclamation project, and deliver said water to less than 2,000 acres of land; (2) all contractors that receive only municipal and industrial (urban) water from any federal reclamation project, and provide said water to less than 3,300 people; and (3) all contractors that receive less than an annual average of 2,000 acre feet from any federal reclamation project. Id.
83. 1996 Criteria, at p. 6; 1999 Draft Criteria, at p. 4; 2002 Draft Criteria, at p. 5.
84. 2002 Draft Criteria, at p. 5.
85. 2002 Draft Criteria, at p. 6; see also 1996 Criteria, at p. 8.
86. 2002 Draft Criteria, at p. 9.
87. 2002 Draft Criteria, at p. 9; see also 1996 Criteria, at pp. 10-11. In quantifying water used, plans are required to state: (a) conveyance losses, including seepage, evaporation, and operational spills; (b) consumptive use by riparian vegetation; (c) applied irrigation water, crop evapotranspiration, water used for leaching and cultural practices (frost protection, soil reclamation, etc.); (d) urban water use; (e) ground water recharge; (f) water exchanges, transfers and banking; (g) estimated deep percolation within the District; (h) flows to perched water table or saline sink; (i) total urban waste water utilized within the system; (j) irrigation spill or drain water leaving the District; and (k) other.

AGRICULTURAL CONTRACTORS

Agricultural BMPs deemed "critical" are those which all districts "will implement or are already implementing." In regard to water use measurement, the critical agricultural BMPs in the 1996 Criteria called for districts to

> "measure, with a device that is rated to have a maximum error of six percent, the volume of water delivered by the District to each customer (within five years of contract renewal or if no contract renewal date, by January 1, 1999)"[88]

The critical BMPs under the 1999 Draft Criteria called for districts to

> "Measure and maintain, to a reasonable degree of accuracy, the volume of water delivered by the Contractor to each customer."[89]

The critical BMPs under the 2002 Draft Criteria call for contractors to

> "Measure the volume of water delivered by the Contractor to each customer. Measure flows with devices that are operated and maintained to a reasonable degree of accuracy, under most conditions, to ± 6% by volume. Three typical categories of measurement devices are: devices with totalizers, standard flow measurement devices, and non-standard but calibrated devices. In most cases this requires a device, which continuously records conditions such as flow or water level during delivery."

The 2002 Draft Criteria further describe the categories of measurement devices:

> "The first category includes devices with totalizers that measure volume: propeller meters, Venturi meters, magnetic meters, and acoustic meters. These have a high level of accuracy with proper installation and periodic maintenance and calibration.
>
> "The second category includes standard flow measurement devices that measure flow rate and also require accurate measurements of water level and delivery time to determine volumes: Replogle and Parshall flumes; rectangular, trapezoidal (Cipolletti) and V-Notch weirs; and canal meter gates. These devices require proper installation; continuous recording of water levels and

88. 1996 Criteria, at p. 12.
89. U.S. Bureau of Reclamation, Mid-Pacific Region, Criteria for Evaluating Water Management Plans (1999) ["1999 Draft Criteria"], at p. 9.

flow rates; delivery beginning and ending times; adjustments for approach velocity in some cases; and regular maintenance and calibration for good accuracy.

"The third category includes non-standard, calibrated flow measurement devices. This category includes special measurement devices developed by a District. Typically, there are no published standard dimensions or flow tables for such devices. Consistent dimensions and installations; accurate determination of delivery time; local calibration and a verification of accuracy, based on a representative sample number of devices measured over time; and a proposed schedule for maintenance and calibration would be necessary for acceptability.

"Rough estimates or instantaneous measurements of flow rate or volume are not acceptable since such measurements do not provide a documented reasonable degree of accuracy. Examples are, flow rate estimates at check structures, the sum of the flow in siphon tubes, the use of occasional flow readings and multiplying by the time between readings, or other methods of measurement not specified here."[90]

In contrast with "critical" BMPs which are considered universally applicable, "exemptible" BMPs are those which a contractor will implement "unless the Contractor provides adequate documentation that supports an exemption or states the reason the BMP is not applicable…"[91] One of the "exemptible" agricultural BMPs described in the 2002 Draft Criteria is measurement of district outflow, under which contractors will:

"Measure at least 80% of the water that leaves control of the Contractor and eventually leaves the district boundary within 10 years. Measure flow with devices that are operated and maintained to a reasonable degree of accuracy, under most conditions, to ± 6% of volume."[92]

The 1999 Draft Criteria also attempt to integrate the Bureau of Reclamation's review of agricultural Water Management Plans with review by the Agricultural Water Management Council ("AWMC"), to the extent possible.[93]

URBAN CONTRACTORS

The 2002 Draft Criteria state that the urban BMPs "will be evaluated based on the California Urban Water Conservation Council (CUWCC) Memorandum of Understanding, amended March 14, 2001."[94] The CUWCC Memorandum of Understanding ("MOU"), by its terms, applies only to signatories of the MOU. The Bureau of Reclamation's criteria draw from the MOU and make the MOU BMPs applicable to all Bureau contractors subject to the criteria, regardless of whether the contractor has also signed the MOU.

All signatories to the MOU are required to make only "a good faith effort" to implement each BMPs, and certain exceptions apply as well. Under the Bureau's criteria, certain BMPs are considered "critical" or "not exemptible," while others are considered "exemptible." Under 1996 Criteria, the following were considered not exemptible:

- metering with commodity rates for all new and existing connections;
- distribution system water audits, leak detection and repair;
- landscape efficiency requirements for new/existing commercial, industrial, institutional, governmental and multi-residential developments;
- public information;
- school education;
- new commercial, industrial and institutional water use review;
- conservation pricing (water and sewer service);
- water waste prohibition;
- demand management staff; and
- financial incentives.

The 1999 Draft Criteria added several BMPs, but rendered all BMPs exemptible with the exception of "metering with commodity rates, for all new connections and retrofit of existing connections."[95] Under the 2002 Draft Criteria, as well, metering is the only non-exemptible BMP.[96]

The Bureau attempts to harmonize its procedures with the CUWCC MOU procedures by specifying that:

"Urban Contractor can complete an annual update by filling in the information for Urban BMPs on the CUWCC website. Contractors who are signatories of the CUWCC are currently submitting annual reports via the CUWCC's *BMP Reporting Database* located on their website at www.cuwcc.org. Through an agreement with the CUWCC, Reclamation's urban non-signatories may now submit their Annual Reports through the CUWCC's website using 'guest accounts.' Urban BMPs are reviewed based on the CUWCC's MOU (amended March 14, 2001)."[97]

90. 2002 Draft Criteria, at pp. 10-11.
91. 2002 Draft Criteria, at p. 10.
92. 2002 Draft Criteria, at p. 13.
93. 1999 Draft Criteria, at p. 3; 2002 Draft Criteria, at p. 19.
94. 2002 Draft Criteria, at p. 14.
95. 1999 Draft Criteria, at p. 10.
96. 2002 Draft Criteria, at p. 14.
97. 2002 Draft Criteria, at p. 15.

WATER FORUM AGREEMENT

In 2000, a number of local governments and other organizations in the Sacramento region executed the Memorandum of Understanding for the "Water Forum Agreement."[98] Pursuant to that MOU, the signatories agreed to endorse and participate in implementing the Water Forum Agreement, which provided for a set of diversions and facilities for various purveyors, as well as a specified set of actions appropriate to certain signatories.[99]

The Water Forum Agreement "adapted" the BMPs from the CUWCC MOU. Under the Water Forum Agreement, purveyors will adopt and implement Water Conservation Plans, incorporating these BMPs.[100]

RESIDENTIAL METER RETROFIT AND CONSERVATION PRICING

Two of the applicable BMPs are (1) residential meter retrofit and (2) conservation pricing. The Water Forum Agreement recognizes that, in terms of the extent to which these BMPs are currently being implemented, there are five classes of purveyors:

- *Purveyors that are already fully metered and use volumetric billing.* As to these purveyors, no further requirements are imposed for these BMPs.

- *Purveyors that are, or will become, users of Central Valley Project water supplies, and therefore subject to the water conservation provisions of the Central Valley Project Improvement Act.* As to these purveyors, meter retrofits are already required by the Bureau of Reclamation. The Water Forum Agreement requires that, "if for any reason any or all of their service area is not immediately or in the future subject to the CVPIA meter retrofit requirement, beginning no later than the start of the fourth year after the Water Forum Agreement is signed they would annually retrofit at least 3.3%-5% of the total number of unmetered residential connections as of the date of the Water Forum Agreement."[101]

- *Purveyors that are not subject to the CVPIA requirements and are not totally reliant on groundwater.* Beginning no later than the start of the fourth year after the Water Forum Agreement is signed these purveyors would retrofit at least 3.3%-5% of the total number of unmetered residential connections as of the date of the Water Forum Agreement.[102]

- *Purveyors that are not subject to the CVPIA requirements and are currently totally reliant on groundwater.* These purveyors will implement a program of "active voluntary meter retrofit with incentives." Also, "[a]t such time as any of these purveyors needs discretionary approvals for new or expanded surface water supplies they agree to annually retrofit at least 3.3%-5% of the total number of unmetered residential connections…"[103]

- *City of Sacramento.* The City of Sacramento has a provision in its charter prohibiting mandatory residential meters. The City will implement a voluntary meter retrofit program.[104]

Purveyors who signed the MOU, also agree not to "implement local retrofit on resale, or any other requirements that would impose escrow or disclosure responsibilities on realtors," except for "voluntary meter retrofit at time of resale that would not impose escrow or disclosure requirements."[105]

Signatories further agree to "[a]s soon as practical… implement conservation pricing which bases customer charges on the quantity of water used." Each purveyor has a different schedule for implementing this provision, with a general guideline being six years.[106]

DISTRIBUTION SYSTEM WATER AUDITS, LEAK DETECTION AND REPAIR

In the Water Forum Agreement, purveyors agree to start implementing certain BMPs within three years of the signing of the agreement.[107] BMPs in this category include "BMP 3," which applies to distribution system water audits, leak detection and repair. Within this BMP is the requirement that signatories will complete and be maintaining "an ongoing meter calibration and replacement program for all production and distribution meters."[108]

AUTHORITIES OF BOTH STATE WATER RESOURCES CONTROL BOARD AND DEPARTMENT OF WATER RESOURCES

"The department and board shall take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state."[109]

98. For a listing of Water Forum members, see the organization's website at http://www.waterforum.org/MEMBER.HTM.
99. The MOU and Water Forum Agreement "are intended to embody general principles agreed upon between and among the signatories but they are not intended to, and do not, create contractual relationships, rights, obligations, duties or remedies enforceable in a court of law by, between, or among the signatories or any third parties." MOU for the Water Forum Agreement, sec. F.
100. Water Forum Agreement (January 2000), at p. 89.
101. Water Forum Agreement, at p. 90.
102. Water Forum Agreement, at p. 90.
103. Water Forum Agreement, at p. 90.
104. Water Forum Agreement, at p. 90.
105. Water Forum Agreement, at p. 91.
106. Water Forum Agreement, at p. 92.
107. Water Forum Agreement, at p. 92.
108. Water Forum Agreement, at p. 351.
109. Cal. Water Code, § 275.

AUTHORITIES OF THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

The California Department of Water Resources ("DWR") has several powers and authorities pertaining to measurement of water use. DWR "may" do any of the following:

- "[C]arry on… investigations into matters pertaining to the water resources of the State along the lines of hydrography, hydroeconomics, and the use and distribution of water for agricultural purposes…"[110]
- "Conduct investigations of the rate of use of water for various purposes and considering various soil conditions."[111]
- "Collect records of diversion and use of water."[112]
- "Conduct investigations of all or any portion of any stream, stream system, lake or other body of water."[113]

DWR "is authorized to":

- "[C]ollect hydrologic data necessary for river forecasting, to make forecasts of stream flow, to provide for flood warning, and to provide for communication necessary for the collection and dissemination of such information."[114]

Pursuant to statute, DWR "shall":

- "[C]onduct surveys and investigations relating to the reclamation of water from wastes for beneficial purposes, including but not limited to the determination of quantities of such water presently wasted, and possibilities of use of such water for recharge of underground storage or for agricultural or industrial uses."[115]

- "[I]nvestigate conditions of the quality of all waters within the state, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature…"[116]

DWR or any other public agency that supplies water for agricultural use may:

- Institute a water conservation or efficient water management program, including, among other things, "[u]sing flow measuring devices in the delivery system and providing to farmers, or assisting farmers in the use of, on-farm flow measurement devices."[117]

"The department shall update The California Water Plan on or before December 31, 2003, and every five years thereafter."[118] Since 1966, DWR has fulfilled its duty to publish The California Water Plan by publishing the Bulletin 160 series.[119]

As part of updating The California Water Plan every five years, DWR must conduct a study to determine the amount of water needed to meet the state's future needs and to recommend programs, policies, and facilities to meet those needs. One year prior to issuing each update to The California Water Plan, DWR must release a preliminary draft of the assumptions and other estimates upon which the study will be based. DWR must release, at a minimum, assumptions and other estimates relating to all of the following:

- Basin hydrology, including… consumptive uses.
- Environmental water needs, including… regulatory instream flow requirements, nonregulated instream uses, and water needs by wetlands, preserves, refuges, and other managed and unmanaged natural resource lands.
- Current and projected water use for all of the following:
  - — Interior uses in a single-family dwelling.
  - — Exterior uses in a single-family dwelling.
  - — All uses in a multifamily dwelling.
  - — Commercial uses.
  - — Industrial uses.
  - — Parks and open spaces.[120]

AUTHORITIES OF THE STATE WATER RESOURCES CONTROL BOARD

STATEMENTS OF WATER DIVERSION AND USE

With specified exceptions, "Each person who, after December 31, 1965, diverts water shall file with the [State Water Resources Control Board], prior to July 1 of the succeeding year, a statement of his diversion and use."[121] This applies to diverters under riparian rights and diverters under pre-1914 appropriative rights. In such statements, "Those who maintain water-measuring devices and keep monthly records of water diversions shall state the quantity of water diverted by months during the preceding calendar year. Others shall state the acreage of each crop irrigated, the average number of people served with water, the average number of stock watered, and the nature and extent of any other use during the preceding calendar year, or such other equivalent information tending to indicate the quantity of water used as may be prescribed by the board."[122] After filing of the initial statement, supplemental statements are due at three-year intervals.[123]

110. Cal. Water Code, § 225.
111. Cal. Water Code, § 226(e).
112. Cal. Water Code, § 226(c).
113. Cal. Water Code, § 226(a).
114. Cal. Water Code, § 236.
115. Cal. Water Code, § 230.
116. Cal. Water Code, § 229.
117. Cal. Water Code, § 10522(b)(1).
118. Cal. Water Code, § 10004.
119. Department of Water Resources, Bulletin 160-98 (November 1998), at p. iii.
120. Cal. Water Code, § 10004.6.
121. Cal. Water Code, § 5101; see also Cal. Water Code, § 5102.
122. Cal. Water Code, § 5103(d).
123. Cal. Water Code, § 5104.

SUITABLE MEASURING AND RECORDING DEVICES

"After issuance of a permit for surface diversion or storage or underground storage the permittee may be required to establish suitable measuring and recording devices and to obtain and furnish to the board such records as may be needed to determine with reasonable accuracy: the quantity of water beneficially used; or the quantity of water placed in storage and the quantity later recovered under the provisions of the permit. Permittee may also be required to determine and submit a written statement of the quantities beneficially used."[124]

REPORTS OF LICENSEE

State Water Resources Control Board staff who were interviewed indicated that following the water rights Application process, and following issuance of a permit, the permittee is required to submit a Progress Report of Permittee each year.[125] Upon completion of the diversion project and perfection of the water right, a License is issued. The Licensee is required to submit a Report of Licensee every three years for the life of the water right. The required Report of Licensee specifies, among other things the amount of water taken.

NOTICES OF EXTRACTIONS AND DIVERSIONS OF WATER

Since 1955, certain measurement rules apply in the Counties of Riverside, San Bernardino, Los Angeles, and Ventura.[126] In those Counties, persons extracting more than 25 acre-feet of groundwater per year shall file with the State Water Resources Control Board a "Notice of Extraction and Diversion of Water," with certain exceptions. Among other things, the notice must state the "quantity of water taken and the method of measurement used by such person or his predecessor in interest in each preceding year from each surface or ground water source" going back ten years.[127] In other words, extraction of groundwater in excess of 25 acre-feet triggers the requirement of filing a notice as to both surface and groundwater. The State Board implements this through issuance of separate "first notice" forms for groundwater extractions and surface water diversions, and separate "annual notices" after filing of the first notices. The State Board has stated that the measurement information obtained through the program "will materially assist in establishing the rights of users to water in the event a judicial determination of rights is invoked to assure orderly and efficient use of water from a common ground water source."[128]

State Water Resources Control Board staff who were interviewed emphasized that, while the filing of the notices is mandatory, the consequence for noncompliance with the filing requirement is merely that the historical water use information is unavailable to the water user in the event an adjudication occurs. In addition, staff indicated that, as a whole, the degree of accuracy of the data submitted is such that it does not lend itself to aggregation. Individual persons submitting data do not always submit accurately calculated information. The submittals do serve as indicators that extractions are occurring at particular locations.

MEASUREMENT IN WATERMASTER SERVICE AREAS

Under state law, owners of conduits and certain reservoirs within watermaster service areas are required to "construct and maintain such water flow measuring devices at such points along the conduit as may be required and approved by the department [of water resources] for the purpose of assisting the watermaster in determining":

- as to the conduits, the amounts of water "which are being diverted and applied to beneficial use";[129]
- as to the reservoirs, the amounts of water "to which the owner is entitled and the amounts of water which the owner is diverting, storing, and applying to beneficial use."[130]

GROUNDWATER MANAGEMENT PROGRAMS UNDER THE GROUNDWATER MANAGEMENT ACT OF 1992 (A.B. 3030), AS AMENDED

Any local agency can adopt a groundwater management plan.[131] The plan may include components relating to, for example, control of saline water intrusion, facilitating conjunctive use operations, and others.[132] With some exceptions, a local agency that adopts a groundwater management plan may, after an election by a majority of those voting, impose equitable annual fees and assessments for groundwater management based on the amount of groundwater extracted from the groundwater basin within the plan area to pay for costs incurred by the local agency for groundwater management.[133] The Local Groundwater Management Assistance Act of 2000 (A.B. 303) created a fund to be administered by DWR for grants to agencies to carry out activities to manage groundwater.[134]

DWR staff who were interviewed did not identify any adopted groundwater management plans that include provisions relating to measurement. Because of the decentralized nature of the groundwater management plan process, however, not all such plans come to DWR's attention.

124. Cal. Code of Regulations, tit. 23, § 846.
125. Cal. Code of Regulations, § 847.
126. Cal. Water Code, § 4999.
127. Cal. Water Code, § 5002(b).
128. Information Relating to Recordation of Water Extractions and Diversions in Riverside, San Bernardino, Los Angeles and Ventura Counties, 91-3 WR, State of California Water Resources Control Board (June 1991), p. 1.
129. Cal. Water Code, § 4103; see also Cal. Water Code, § 4104.
130. Cal. Water Code, § 4125; see also Cal. Water Code, § 4126.
131. Cal. Water Code, § 10753(a).
132. Cal. Water Code, § 10753.7.
133. Cal. Water Code, §§ 10754.2, 10754.3.
134. Cal. Water Code, §§ 10795-10795.20.

GROUNDWATER MANAGEMENT DISTRICTS

Several statutes have been enacted that create particular groundwater management districts having particular powers.[135] Most of these statutes empower the districts to require or engage in measurement of water use. Each of the statutory districts is in a different stage of implementation, both in regard to general operational matters such as appointment of Board members and in regard to specific programmatic matters such as establishing or carrying out measurement requirements. Below are representative provisions that are found in some of the distinct legislative acts that pertain to such districts.

REQUIRED REGISTRATION AND MEASUREMENTS

"The district may require extraction facilities to be registered with the district and measured with a water flow measuring device installed and calibrated by the district or, at its option, by the extraction facility operator. The district may also require any new extraction facility which is constructed, existing extraction facility which is deepened, or abandoned extraction facility which is reactivated to be registered with the district within 60 days of completion of construction, deepening, or reactivation, and measured with a water flow measuring device installed and calibrated by the district or, at its option, by the extraction facility operator."[136] As to some districts, the statute provides that the district "shall" require measuring devices.[137]

UNLAWFUL EXTRACTION AND CIVIL LIABILITY

"No person may extract groundwater from any extraction facility required to be registered unless the extraction facility has been registered with the district and, if required, has a water flow measuring device affixed. Any person who does not comply with this section shall be liable civilly for a sum not to exceed one thousand dollars ($ 1,000) for each day this section is not complied with…"[138]

GROUNDWATER EXTRACTION STATEMENT

The district may require the operator of each extraction facility to file with the district "a statement relative to groundwater extraction, including, but not limited to, the gallons per minute which may be extracted from each extraction facility, the static groundwater level for each extraction facility, a general description or number locating each extraction facility, use and acreage served by the extraction facility, and the method of measuring or computing groundwater extraction."[139] Such statements may also be required to include total extraction in acre-feet of water from the extraction facility for the preceding year, and the soil and crop types for agricultural uses.[140]

ALTERNATIVE METHODS FOR ESTIMATING WATER USE

"When a water-measuring device is not permanently attached to a water-producing facility, the board may establish a method or methods to be used in computing the amount of water produced from such water-producing facilities. [¶] Such methods may be based upon any, or all, or a combination of some of the following criteria: the minimum charge sufficient to cover administrative costs of collection, size of water-producing facility discharge opening, area served by the water-producing facility, number of persons served by the water-producing facility, use of land served by the water-producing facility, crops grown on land served by the water-producing facility, or any other criteria which may be used to determine with reasonable accuracy the amount of water produced from such water-producing facility."[141]

RECORD OF EXTRACTION ACCURACY AND INVESTIGATION

"When a water flow measuring device is used at an extraction facility, the record of extraction, as disclosed by the water flow measuring device, shall be presumed to be accurate and shall be used as the basis for computing the water extraction of the extraction facility in completing the groundwater extraction statement. The district may require proof of the accuracy of the water flow measuring device from the operator and may, absent adequate proof of accuracy, order the operator to have the water flow measuring device calibrated in a manner acceptable to the district. If the district has probable cause to believe that the extraction of groundwater from any extraction facility is in excess of the amount reported in groundwater extraction statements, or if no statements are filed covering an extraction facility, the district may investigate the extraction of water from each such extraction facility."[142]

CIVIL LIABILITY

"Any person who does not file a groundwater extraction statement, if required to do so, or any person who injures, alters,

135. See, e.g., Fox Canyon Groundwater Management Agency, Cal. Uncod. Water Deer., Act 2750 (2001); Honey Lake Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 2793 (2001); Monterey Peninsula Water Management District Law, Cal. Uncod. Water Deer., Act 5065 (2001); Ojai Basin Groundwater Management Agency Act, Cal. Uncod. Water Deer., Act 7140B (2001); Orange County Water District Act, Cal. Uncod. Water Deer., Act 5683 (2001); Pajaro Valley Water Management Agency, Cal. Uncod. Water Deer., Act 5695, (2001); Santa Clara Valley Water District Act, Cal. Uncod. Water Deer., Act 7335 (2001); Sierra Valley and Long Valley Groundwater Basins, Cal. Uncod. Water Deer., Act 7662 (2001); Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 (2001).
136. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 601 (2001).
137. Ojai Basin Groundwater Management Agency Act, Cal. Uncod. Water Deer., Act 7140B, § 804 (2001).
138. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 603 (2001).
139. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 604 (2001).
140. Pajaro Valley Water Management Agency, Cal. Uncod. Water Deer., Act 5695, § 603, subds. (a) & (d) (2001).
141. Monterey Peninsula Water Management District Law, Cal. Uncod. Water Deer., Act 5065, § 354 (2001).
142. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 605 (2001).

removes, resets, adjusts, manipulates, obstructs, or in any manner interferes or tampers with, or procures, causes, or directs any person to injure, alter, remove, reset, adjust, manipulate, obstruct, or in any manner interfere or tamper with, any water flow measuring device affixed to any extraction facility as required by this act so as to cause the water flow measuring device to improperly or inaccurately measure and record water extraction, or any person who, with intent to evade any provision or requirement of this act, files with the district any false or fraudulent groundwater extraction statement, shall be liable civilly in a sum of not more than one thousand dollars ($1,000)."[143]

BASIS OF CALCULATING GROUNDWATER EXTRACTION CHARGES

"Groundwater extraction charges shall be calculated on the basis of groundwater extraction statements required to be filed pursuant to this act."[144]

INJUNCTIVE RELIEF AGAINST NONCOMPLIANCE

"Upon the failure of any person to comply with any of the provisions of this act, including, but not limited to, the registration of extraction facilities and installation of measuring devices, filing of statements, payment of extraction charges, or payment of management charges, or upon the failure of any person to comply with any ordinance adopted by the board of directors pursuant to this act, the district may petition the superior court of the county for a temporary restraining order or preliminary or permanent injunction prohibiting the person from operating an extraction facility or for other injunctive relief that may be appropriate."[145]

TRANSFERS AND CONJUNCTIVE USE

There are several different types of water transfers that can occur under California and federal law. The measurement requirements associated with each statutory type of transfer are described below. In addition to these, individual state or federal contracts may contain provisions regarding transfers.

Certain measurement requirements are also associated with conjunctive use of surface and groundwater, as described below. In general, to avoid losing a water right through one of these approaches, a user may be required to document the previous use of water proposed to be foregone in the future.

TEMPORARY URGENCY CHANGES UNDER WATER CODE, §§ 1435-1442

Before issuing an order allowing a "temporary urgency change," the State Water Resources Control Board must find, among other things, that: (1) the permittee urgently needs the change; (2) the change will not injure any other lawful user; (3) the change will not unreasonably effect fish or wildlife; and (4) the change is in the public interest.[146] Before making necessary findings, the State Board must review available records which relate to the rights of other legal users. (Water Code, § 1437.)

TEMPORARY CHANGES UNDER WATER CODE, §§ 1725-1732

The State Board must approve a proposed "temporary change" if: (1) the change would not injure any legal user of water through, among other things, significant changes in water quantity; and (2) the proposed change would not unreasonably affect fish and wildlife.[147] Before approving a petition for change, the State Board must determine "if the water proposed to be transferred would have been consumptively used or stored pursuant to petitioner's permit or license in the absence of the proposed transfer or conserved pursuant to Section 1011."[148] Petitioners for temporary changes are not allowed to initiate or increase the use of groundwater to replace surface water transferred by their petition, except in limited circumstances.[149]

LONG-TERM TRANSFERS UNDER WATER CODE, §§ 1735-1737

The State Board may approve a petition for a "long-term transfer" where the change would not result in substantial injury to any legal user of water and would not unreasonably affect fish and wildlife.[150]

SURPLUS WATER TRANSFERS UNDER WATER CODE, §§ 380-387

Local or regional public agencies authorized to serve water within a service area may sell, lease, exchange, or otherwise transfer water for use outside the agency if the water is: (1) surplus to the needs of the water users of the agency; or (2) voluntarily foregone during the period of the transfer by a water user of the agency.[151] The State Board can approve a petition for a long-term transfer under these provisions where the change would not result in substantial injury to any legal user of water, would not unreasonably affect fish and wildlife, and would not unreasonably affect the overall economy of the area from which the water is being transferred. When a transfer under section 382 is of conserved water, the user's water rights are protected under Water Code section 1011, which recognizes conservation as a reasonable and beneficial use.

143. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 607 (2001).
144. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 805 (2001).
145. Willow Creek Valley Groundwater Basin Act, Cal. Uncod. Water Deer., Act 9171 § 1201 (2001).
146. Cal. Water Code, § 1435(b).
147. Cal. Water Code, § 1727(b).
148. Cal. Water Code, § 1726(e).
149. Cal. Water Code, § 1732.
150. Cal. Water Code, § 1736.
151. Cal. Water Code, § 382.

When a user is seeking the benefit of section 1011, the State Board may require that user to "file periodic reports describing the extent and amount of the reduction in water use due to conservation efforts."[152] Similar provisions apply in the case reductions of use as the result of use of recycled, desalinated or polluted water.[153]

TRANSFERS OF WATER CONSERVED OR AVAILABLE THROUGH CONTRACTS UNDER WATER CODE, §§ 1745-1745.11

A water supplier (either a public agency or private company supplying or storing water) may transfer water to a state drought water bank or to any other water supplier or user.[154] The water supplier may only do so if no other user will receive less than the amount provided by their allocation for that year or be otherwise unreasonably adversely affected without their consent.[155] Water that can be transferred by this method includes conserved water or water made available pursuant to a contract by the user to reduce their use (including by fallowing).[156] The amount of water made available by land fallowing may not exceed 20 percent of the water that would have been applied or stored by the water supplier in the absence of any contract under these provisions.[157]

CONJUNCTIVE USE—PUMPING IN LIEU OF USING SURFACE WATER

If use of surface water under an appropriative right is replaced by groundwater pumping, the reduction in use of the surface water is a reasonable and beneficial use "to the extent of the cessation of, or reduction in, use, and to the same extent as the appropriated water was put to reasonable and beneficial use by that person."[158] The State Board may require any holder of an appropriative right who seeks the benefit of this section 1011.5 "to file periodic reports describing the extent and amount of the reduction in water use due to substitution of an alternate supply."[159]

152. Cal. Water Code, § 1011(a).
153. Cal. Water Code, § 1010.
154. Cal. Water Code, §§ 1745, 1745.02, 1745.04.
155. Cal. Water Code, § 1745.04.
156. Cal. Water Code, § 1745.05(a).
157. Cal. Water Code, § 1745.05(b).
158. Cal. Water Code, § 1011.5(b).
159. Cal. Water Code, § 1011.5(b).

CONJUNCTIVE USE—USE OF SURFACE WATER IN LIEU OF PUMPING.

Use of surface water in lieu of groundwater extraction is a reasonable and beneficial use if the surface water is imported or is conserved by a water conservation plan.[160] Any user of imported or conserved water seeking the benefit of this section 1005.1 "shall file" with the State Board and annual "statement of the amount" of imported or conserved water applied to reasonable beneficial use pursuant to the provisions of section 1005.1 during the previous water year.

Replenishment of groundwater through cessation or reduction in extraction due to use of water that is imported or is conserved through a conservation plan is also a reasonable and beneficial use.[161] Any water user seeking the benefit of these sections "shall file" with the State Board a statement of the amounts of the reduction in the extraction of ground water due to use of imported or conserved water during the previous water year.

CVPIA TRANSFERS

Under the federal Central Valley Project Improvement Act, recipients of Central Valley Project water may transfer that water, but the amount transferred may not exceed in one year the average of water delivered during the last three normal delivery years prior to October 30, 1992. The water subject to any such transfer "shall be limited to water that would have been consumptively used or irretrievably lost to beneficial use during the year or years of the transfer."[162] Pursuant to Bureau of Reclamation interim guidelines implementing these provisions, "Crop consumptive use" is "the total evapotranspiration of applied water minus effective precipitation and does not include transportation losses, return flows, leaching, frost protection, or deep percolation to usable groundwater basins." "Project water irretrievably lost to beneficial use" is "deep percolation to an unusable groundwater aquifer (e.g., a saline sink or a groundwater aquifer that is polluted to the degree that water from that aquifer cannot be directly used)."[163]

160. Cal. Water Code, § 1005.1.
161. Cal. Water Code, §§ 1005.2, 1005.4.
162. Central Valley Project Improvement Act (CVPIA), Pub. L. 102-575, title XXXIV, § 3405(a)(1)(A)&(I), Oct. 30 , 1992, 106 Stat. 4706.
163. Interim Guidelines for Implementation of the Water Transfer Provisions of the Central Valley Project Improvement Act (October 28, 1999).

APPENDIX B: WATER USE MEASUREMENT AUTHORITIES

TEXT OF STATE WATER RESOURCES CONTROL BOARD STANDARD PERMIT TERMS REQUIRING MEASUREMENT

TERMS DIRECTLY REQUIRING MEASUREMENT (DIVERSIONS AND RESERVOIR RELEASES)

Permit Term R **Title: Measuring Devices – Direct Diversion**

When Used: For direct diversion when a formal record of the quantity of water diverted is desired.

Term: Permittee shall install and maintain devices satisfactory to the State Water Resources Control Board to measure (the instantaneous rate of diversion and cumulative quantity of water diverted under this permit)[a]. (the daily quantity of water diverted under this permit)[b]. A record of such measurements shall be maintained by the permittee, and made available to interested parties upon reasonable request. (A copy of the records shall be submitted to the State Water Resources Control Board with the annual "Progress Report by Permittee")[c].

Permittee shall allow (name of party), or a designated representative, reasonable access to measuring devices for the purpose of verifying measurement readings.

a) for direct diversion in cubic feet per second or gallons per minute.

b) for direct diversion in gallons per day.

c) Use when it is anticipated that the measurement records will definitely be needed by the Board.

(000000R)

Permit Term 46 **Title: Measuring Devices – Offstream Storage**

When Used: For offstream storage, as needed.

Term: Permittee shall install and maintain devices satisfactory to the State Water Resources Control Board to measure the rate and quantity of water diverted into the reservoir from , and water released from or flowing out of the reservoir*

(0060046)

* Delete last clause if not applicable to the particular situation.

Permit Term 85A **Title: Diversion Restriction – Napa Valley**

When Used: For direct diversion and storage after March 15 for frost protection, irrigation, and/or heat control from the Napa River or its tributaries. Do not use on tributaries if frost protection is not a purpose of use or for onstream winter storage on small tributaries. Do not use on Conn Creek above Lake Hennessey.

Term: Diversion of water between March 15 and May 15 is subject to control under a water distribution program administered by the State Water Resources Control Board or by the Department of Water Resources. Whenever such a program is in effect at the project location, permittee shall comply with the following:

A. Diversion after March 15 is contingent upon participation in the water distribution program by permittee.

B. Diversion after March 15 shall be solely to replenish water stored prior to March 15 unless otherwise authorized by the Watermaster in charge of the distribution program.

C. Prior to making diversions after March 15, permittee shall install and maintain devices, satisfactory to the Watermaster, which are capable of measuring the instantaneous rate of diversion and the total amount of water diverted during participation in the distribution program.

D. Permittee's participation in any water distribution program required under the terms of this permit shall be evidenced by returning the information sheet distributed prior to the frost season and paying costs as apportioned at the end of the season.

E. The water distribution program required under this permit may be revised periodically by the State Water Resources Control Board provided that the program shall be substantially consistent with terms of any water distribution program imposed on similarly situated users by the Napa County Superior Court.

(0000085A)

Permit Term 86 **Title: Upper Putah Creek – Direct Diversion**

When Used: Terms and conditions for continuation permits and new permits pursuant to SWRCB order WR 96-002 (Section 7.1 WR 96-002, pg 11-15). For direct diversion from Putah Creek and its tributaries upstream from the Solano project of the USBR (drainage into Lake Berryessa).

Term: Permittee shall comply with the following provisions which are derived from the Condition 12 Settlement Agreement dated March 10, 1995 (Agreement) pursuant to the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565:

(1) Permittee is hereby put on notice that the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565, has retained jurisdiction over the parties and, upon application by the watermaster, has the right to temporarily enjoin the diversion of water under this permit for noncompliance with the terms of the Agreement.

(2) Diversion of water under this permit shall be subject to the watermaster appointed by the court to enforce the terms of the Agreement. The permittee shall be responsible for partial payment of the watermaster costs in accordance with the terms of the Agreement.

(3) Permittee shall maintain a device, satisfactory to the SWRCB, which is capable of measuring water directly diverted under this permit. A satisfactory device includes: For Pumping Stations: (1) In-line flow meter having instantaneous and total flow reading capability, or (2) Proof of a pump test performed within the last 5 years together with official monthly power consumption records for the electric meter serving the pump. For Gravity Diversions: A weir, flume, or other flow measuring device that is properly installed, or a flow-rating curve established by volumetric measurements.

(4) Permittee shall maintain monthly records of direct diversion from March I to July 15 of each year, or such other period as may be specified with written notice to the permittee by the watermaster.

(5) Permittee shall report to the watermaster annually, all diversions under this permit by September 1 of each year on forms approved by the watermaster.

(6) Permittee shall allow the watermaster reasonable access to the project covered by this permit to inspect measuring equipment and to observe compliance with these permit terms and conditions, upon 48-hour prior notice and upon such reasonable conditions as permittee may prescribe.

(7) Permittee is hereby put on notice that there may be years when diversion of water under this permit will not be within the reservation of water established for the Putah Creek watershed upstream of Monticello Dam, as set forth in the Agreement and that in those years no water may be available under this permit, and that releases of stored water may be required.

(8) Permittee is hereby put on notice that the waiver of priority granted by Reclamation and Solano County Water Agency provides that in the event Allowable Depletion is exceeded in any year, water diverted to storage that year shall be released and/or direct diversions shall be curtailed during the ensuing season(s), when applicable, to the extent necessary to bring the Allowable Depletion into compliance, in the following order:

a. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation Water Rights in excess of 120 percent of that water right holder's previous five-year average, in reverse order of water right priority.

b. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation

APPENDIX B: WATER USE MEASUREMENT AUTHORITIES

TABLE B1. SWRCB WATER RIGHTS PERMIT TERMS REQUIRING MEASUREMENT

PERMIT TERM	TOPIC HEADING	SUMMARY
Terms Directly Requiring Measurement (Diversions & Reservoir Releases)		
R	Measuring Devices – Direct Diversion	Install and maintain measurement devices satisfactory to SWRCB; retain formal record of rate and quantity of water diverted.
46	Measuring Devices – Offstream Storage	Install and maintain measurement devices satisfactory to SWRCB; measure water diverted into and released from or flowing out of reservoir.
85A	Diversion Restriction – Napa Valley	Before diverting water after 3/15, install and maintain measurement devices satisfactory to watermaster.
86	Upper Putah Creek – Direct Diversion	Maintain measurement device satisfactory to SWRCB, to measure direct diversions. "A satisfactory device" is further defined.
87	Upper Putah Creek – On Stream & Offstream Storage	Maintain measurement device satisfactory to SWRCB, to measure diversions to storage. "A satisfactory device" is further defined.
88	Upper Putah Creek – Direct Diversion Plus Storage	Maintain measurement device satisfactory to SWRCB, to measure direct diversions. "A satisfactory device" is further defined.
211 (Term D)	Special Navarro River Terms	Measure rate/quantity of diversion; maintain records for DWR.
B	Purchase From Nevada Irrigation District	For storage on sources affecting NID, measure flow in and out of reservoir.
Terms Directly Requiring Measurement (Underground Storage & Recovery)		
117	Measuring Devices – Underground Storage	Install and maintain measurement device satisfactory to SWRCB; no diversion from underground storage prior to device installation.
Terms Directly Requiring Measurement (Levels/Staff Gages)		
47	Measuring Devices – Reservoir Staff Gage(s)	Install and maintains staff gages satisfactory to SWRCB to measure reservoir levels; report readings to SWRCB.
D1	Tributaries To Clear Lake – Agreement	Install and maintain staff gages satisfactory to SWRCB to measure reservoir levels; calibrated to storage in acre-feet; report readings to SWRCB, YCFC and WCD.
Terms Directly Requiring Measurement (Bypass Flows)		
60	Reservoir Stream Flow Bypass For Fish and Wildlife	Submit Compliance Plan satisfactory to DWR; describe how bypass flows will be measured.
61	Fish And Wildlife Bypass – Napa River	Stream flows shall be measured at nearest USGS Gaging Station or by measuring device acceptable to SWRCB.
62A	Measuring Device For Bypass -- Single, PNB*	Install and maintain measuring device satisfactory to SWRCB prior to diversion.
62AP	Measuring Devices For Bypass -- Multiple, PNB*	Install and maintain measuring device satisfactory to SWRCB prior to diversion.
62B	Measuring Device For Bypass -- Single, PB*	Install and maintain measuring device satisfactory to SWRCB prior to diversion.
62BP	Measuring Device For Bypass -- Multiple, PB*	Install and maintain measuring device satisfactory to SWRCB prior to diversion.
70	Flow Bypass Compliance Plan	Submit Compliance Plan to DWR including description of measuring devices installed (or to be installed); no diversion prior to Plan approval.
200	Fish & Wildlife Protection Bypass Term	Install and maintain measuring device (preferably passive bypass structure) satisfactory to SWRCB.
201	Pulse Flow Bypass Term For Coastal Streams	Install and maintain measuring device (to measure pulse flow) satisfactory to SWRCB.
204	Responsibility For Measuring Device For Bypass (If Using A USGS- Or DWR-Operated Gage)	If stream gages operated by USGS or DWR are not available for stream flow measurements, equivalent gages, satisfactory to DWR, must be installed near inoperable ones.
211 (Term A)	Special Navarro River Terms	If stream gages are not available for stream flow measurements, equivalent gages, satisfactory to DWR, must be installed.
G	Fish Bypass On Lower Pescadero Creek or Butano Creek (San Mateo County)	Install and maintain measuring device satisfactory to SWRCB.
12	Continuing Authority	Specifically mentions imposition of additional measurement requirements as one possible exercise of continuing authority.

* PNB = Project Not Built, PB = Project Built

SOURCES: STATE WATER RESOURCES CONTROL BOARD, DIVISION OF WATER RIGHTS, PERMIT TERMS (MARCH 2001).

Water Rights above the previous five-year average diversion, in reverse order of priority.

c. All remaining water directly diverted and/or diverted to storage that year by holders of Post-Reservation Water Rights in reverse order of priority.

(9) In any year in which Annual Depletion exceeds Allowable Depletion, if Lake Berryessa: (1) does not drop below 640,000 acre-feet in storage as of May 1, permittee shall have three years, starting in the next Accumulation Season, to make up or repay permittee's excess diversions; or (2) does not reach 640,000 acre-feet of storage as of May 1, permittee shall have one year, starting in the next Accumulation Season, to make up or repay permittee's excess diversions. In the event that Lake Berryessa spills at any time prior to full payback of excess depletion, permittee shall be excused from any further obligation for repayment of the overage.

(10) Permittee shall provide watermaster prior notice of any repayment. Repayment may be made either by releases from storage, curtailment of direct diversion, or by the provision of water from other sources.

(11) Permittee shall notify the watermaster of any change in ownership of land, changes in the water right, or changes in address related to the permit.

(12) Permittee is hereby put on notice of permittee's right, upon reasonable prior notice, to inspect and to copy, at permittee's own expense, all records and reports of the watermaster.

(13) Solely for purposes of administering Post-Reservation Depletion, the average annual depletion assigned to this project is acre-feet per annum as calculated by the watermaster using information described in Exhibit C of the Condition 12 Settlement Agreement. Permittee shall notify the watermaster of any change in crop type, acreage irrigated, and irrigation method. Any change in water usage which results in an increase in average annual depletion of more than 10 percent for non-weather related reasons, as determined by the watermaster, will require filing a new water right application. (Agreement pp. 13-15, Exhibit E)

Inclusion in the permit of certain provisions of this Agreement shall not be construed as disapproval of other provisions of the Agreement or as affecting the enforceability, as between the parties, of such other provisions insofar as they are not inconsistent with the terms of this permit.

(0000024)

The State Water Resources Control Board (SWRCB) shall have continuing authority under article X, section 2 of the California Constitution, Water Code Sections 100 and 275, and the common law public trust doctrine over this permit to delete, revise, amend, or adopt new terms or conditions to: (1) implement the March 10, 1995, Condition 12 Settlement Agreement and any amendments to the agreement and (2) make the terms or conditions consistent with any order of the superior court. No action shall be taken pursuant to this paragraph unless the SWRCB provides notice to affected parties and provides an opportunity for a hearing.

(0000012)
(0220086)

Permit Term 87 **Upper Putah Creek – ON STREAM AND OFFSTREAM STORAGE**

When Used: Terms and conditions for continuation permits and new permits pursuant to SWRCB order WR 96-002 (section 7.1 wr 96-002, pg 11-15). For storage in Putah Creek and its tributaries upstream from the Solano Project of the USBR (drainage into Lake Berryessa).

Term: Permittee shall comply with the following provisions which are derived from the Condition 12 Settlement Agreement dated March 10, 1995 (Agreement) pursuant to the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565:

(1) Permittee is hereby put on notice that the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565, has retained jurisdiction over the parties and, upon application by the watermaster, has the right to temporarily enjoin the diversion of water under this permit for noncompliance with the terms of the Agreement.

(2) Diversion of water under this permit shall be subject to the watermaster appointed by the court to enforce the terms of the Agreement. The permittee shall be responsible for partial payment of the watermaster costs in accordance with the terms of the Agreement.

Pick One of the following, based on method of diversion.

For Onstream Storage Projects (correct for multiple reservoirs)*

(3) Within one year of the construction of the reservoir covered by this permit, permittee shall have the capacity of the reservoir surveyed by a registered civil engineer or licensed surveyor. A copy of the survey and area-capacity curve shall be provided to the watermaster and the SWRCB.

(4) Permittee shall install and properly maintain in the reservoir a staff gage, satisfactory to the watermaster and the SWRCB, for the purpose of determining water levels in the reservoir. Permittee shall record the staff gage readings on October 1 of each year and April 30 of the succeeding year, or such other period as may be specified by the watermaster with written notice to the permittee.

For Offstream Storage Projects

(3) Permittee shall install and maintain a device, satisfactory to the SWRCB, capable of measuring water diverted to storage under this permit. Satisfactory devices shall include: For Pumping Stations: (1) In-line flow meter having instantaneous and total flow reading capability, or (2) Proof of a pump test performed within the last 5 years together with official monthly power consumption records for the electric meter serving the pump. For Gravity Diversions: A weir, flume, or other flow measuring device that is properly installed, or a flow-rating curve established by volumetric measurements.

(4) Permittee shall maintain monthly records of diversion to offstream storage from October 1 of each year to April 30 of the succeeding year, or such other period as may be specified with written notice to the permittee by the watermaster.

(5) Permittee shall report to the watermaster annually, all diversions under this permit by September 1 of each year on forms approved by the watermaster.

(6) Permittee shall allow the watermaster reasonable access to the project covered by this permit to inspect measuring equipment and to observe compliance with these permit terms and conditions, upon 48-hour prior notice and upon such reasonable conditions as permittee may prescribe.

(7) Permittee is hereby put on notice that there may be years when diversion of water under this permit will not be within the reservation of water established for the Putah Creek watershed upstream of Monticello Dam, as set forth in the Agreement and that in those years no water may be available under this per-

mit, and that releases of stored water may be required.

(8) Permittee is hereby put on notice that the waiver of priority granted by Reclamation and Solano County Water Agency provides that in the event Allowable Depletion is exceeded in any year, water diverted to storage that year shall be released and/or direct diversions shall be curtailed during the ensuing season(s), when applicable, to the extent necessary to bring the Allowable Depletion into compliance, in the following order:

a. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation Water Rights in excess of 120 percent of that water right holder's previous five-year average, in reverse order of water right priority.
b. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation Water Rights in reverse order of priority.
c. All remaining water directly diverted and/or diverted to storage that year by holders of Post-Reservation Water Rights in reverse order of priority.

(9) In any year in which Annual Depletion exceeds Allowable Depletion, if Lake Berryessa: (1) does not drop below 640,000 acre-feet in storage as of May 1, permittee shall have three years, starting in the next Accumulation Season, to make up or repay permittee's excess diversions; or (2) does not reach 640,000 acre-feet of storage as of May 1, permittee shall have one year, starting in the next Accumulation Season, to make up or repay permittee's excess diversions. In the event that Lake Berryessa spills at any time prior to full payback of excess depletion, permittee shall be excused from any further obligation for repayment of the overage.

(10) Permittee shall provide watermaster prior notice of any repayment. Repayment may be made either by releases from storage, curtailment of direct diversion, or by the provision of water from other sources.

(11) Permittee shall notify the watermaster of any change in ownership of land, changes in the water right, or changes in address related to the permit.

(12) Permittee is hereby put on notice of permittee's right, upon reasonable prior notice, to inspect and to copy, at permittee's own expense, all records and reports of the watermaster.

(13) Solely for the purposes of administering Post-Reservation Depletion, the average annual depletion assigned to this project is _____ acre-feet per annum as calculated by the watermaster using information described in Exhibit C of the Condition 12 Settlement Agreement. Permittee shall notify the watermaster of any change in crop type, acreage irrigated, and irrigation method. Any change in water usage which results in an increase in average annual depletion of more than 10 percent for non-weather related reasons, as determined by the watermaster, will require filing a new water right application. (Agreement pp. 13-15, Exhibit E)

Inclusion in the permit of certain provisions of this Agreement shall not be construed as disapproval of other provisions of the Agreement or as affecting the enforceability, as between the parties, of such other provisions insofar as they are not inconsistent with the terms of this permit.

(0000024)

The State Water Resources Control Board (SWRCB) shall have continuing authority under article X, section 2 of the California Constitution, Water Code sections 100 and 275, and the common law public trust doctrine over this permit to delete, revise, amend, or adopt new terms or conditions to: (1) implement the March 10, 1995, Condition 12 Settlement Agreement and any amendments to the agreement and (2) make the terms or conditions consistent with any order of the superior court. No action shall be taken pursuant to this paragraph unless the SWRCB provides notice to affected parties and provides an opportunity for a hearing.

(0000012)
(0220087)

Permit Term 88 **Upper Putah Creek – Direct Diversion Plus Storage**

When Used: Terms and conditions for continuation permits and new permits pursuant to SWRCB order WR 96-002 (section 7.1 wr 96-002, pg 11-15). For direct diversion plus storage in Putah Creek and its tributaries upstream from the Solano Project of the USBR (drainage into Lake Berryessa).

Term: Permittee shall comply with the following provisions which are derived from the Condition 12 Settlement Agreement dated March 10, 1995 (Agreement) pursuant to the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565:

(1) Permittee is hereby put on notice that the Sacramento County Superior Court, Judicial Council Coordination Proceeding No. 2565, has retained jurisdiction over the parties and, upon application by the watermaster, has the right to temporarily enjoin the diversion of water under this permit for noncompliance with the terms of the Agreement.

(2) Diversion of water under this permit shall be subject to the watermaster appointed by the court to enforce the terms of the Agreement. The permittee shall be responsible for partial payment of the watermaster costs in accordance with the terms of the Agreement.

(3) Within one year of the construction of the reservoir covered by this permit, permittee shall have the capacity of the reservoir surveyed by a registered civil engineer or licensed surveyor. A copy of the survey and area-capacity curve shall be provided to the watermaster and the SWRCB. Permittee shall install and properly maintain in the reservoir a staff gage, satisfactory to the watermaster and the SWRCB, for the purpose of determining water levels in the reservoir. Permittee shall record the staff gage readings on October 1 of each year and April 30 of the succeeding year, or such other period as may be specified with written notice to the permittee by the watermaster.

(4) Permittee shall maintain a device, satisfactory to the SWRCB, which is capable of measuring water directly diverted under this permit. A satisfactory device includes: For Pumping Stations: (1) In-line flow meter having instantaneous and total flow reading capability, or (2) Proof of a pump test performed within the last 5 years together with official monthly power consumption records for the electric meter serving the pump. For Gravity Diversions: A weir, flume, or other flow measuring device that is properly installed, or a flow-rating curve established by volumetric measurements. Permittee shall maintain monthly records of direct diversion from March l to July 15 of each year, or such other period as may be specified with written notice to the permittee by the watermaster.

(5) Permittee shall report to the watermaster annually, all diversions under this permit by September 1 of each year on forms approved by the watermaster.

(6) Permittee shall allow the watermaster reasonable access to the project covered by this permit to inspect measuring equipment and to observe compliance with these permit terms and conditions, upon 48-hour prior notice and upon such reasonable conditions as permittee may prescribe.

(7) Permittee is hereby put on notice that there may be years when diversion of water under this permit will not be within the reservation of water established for the Putah Creek watershed upstream of Monticello Dam, as set forth in the Agreement and that in those years no water may be available under this permit, and that releases of stored water may be required.

(8) Permittee is hereby put on notice that the waiver of priority granted by Reclamation and Solano County Water Agency provides that in the event Allowable Depletion is exceeded in any year, water diverted to storage that year shall be released and/or direct diversions shall be curtailed during the ensuing season(s), when applicable, to the extent necessary to bring the Allowable Depletion into compliance, in the following order:

a. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation Water Rights in excess of 120 percent of that water right holder's previous five-year average, in reverse order of water right priority.

b. All amounts directly diverted and/or diverted to storage by holders of Post-Reservation Water Rights above the previous five-year average diversion, in reverse order of priority.

c. All remaining water directly diverted and/or diverted to storage that year by holders of Post-Reservation Water Rights in reverse order of priority.

(9) In any year in which Annual Depletion exceeds Allowable Depletion, if Lake Berryessa: (1) does not drop below 640,000 acre-feet in storage as of May 1, permittee shall have three years, starting in the next Accumulation Season, to make up or repay permittee's excess diversions; or (2) does not reach 640,000 acre-feet of storage as of May 1, permittee shall have one year, starting in the next Accumulation Season, to make up or repay permittee's excess diversions. In the event that Lake Berryessa spills at any time prior to full payback of excess depletion, permittee shall be excused from any further obligation for repayment of the overage.

(10) Permittee shall provide watermaster prior notice of any repayment. Repayment may be made either by releases from storage, curtailment of direct diversion, or by the provision of water from other sources.

(11) Permittee shall notify the watermaster of any change in ownership of land, changes in the water right, or changes in address related to the permit.

(12) Permittee is hereby put on notice of permittee's right, upon reasonable prior notice, to inspect and to copy, at permittee's own expense, all records and reports of the watermaster.

(13) Solely for purposes of administering Post-Reservation Depletion, the average annual depletion assigned to this project is acre-feet per annum as calculated by the watermaster using information described in Exhibit C of the Condition 12 Settlement Agreement. Permittee shall notify the watermaster of any change in crop type, acreage irrigated, and irrigation method. Any change in water usage which results in an increase in average annual depletion of more than 10 percent for non-weather related reasons, as determined by the watermaster, will require filing a new water right application. (Agreement pp. 13-15, Exhibit E)

Inclusion in the permit of certain provisions of this Agreement shall not be construed as disapproval of other provisions of the Agreement or as affecting the enforceability, as between the parties, of such other provisions insofar as they are not inconsistent with the terms of this permit.

(0000024)

The State Water Resources Control Board (SWRCB) shall have continuing authority under article X, section 2 of the California Constitution, Water Code Sections 100 and 275, and the common law public trust doctrine over this permit to delete, revise, amend, or adopt new terms or conditions to: (1) implement the March 10, 1995, Condition 12 Settlement Agreement and any amendments to the agreement and (2) make the terms or conditions consistent with any order of the superior court. No action shall be taken pursuant to this paragraph unless the SWRCB provides notice to affected parties and provides an opportunity for a hearing.

(0000012)
(0220088)

Permit Term 211 (Term D) **Special Navarro River Terms**

When Used: For projects on the Navarro River (Terms A through D).

Term D: *Term D:* Permittee shall install and maintain measuring devices, satisfactory to the Chief, Division of Water Rights, which are capable of measuring the instantaneous rate of diversion and the cumulative quantity of water diverted under this permit. A record of daily measurements shall be maintained by the Permittee, including readings at the beginning and end of the diversion season. A copy of the measurement records shall be submitted to the Chief, Division of Water Rights, no later than 30 days after the end of each diversion season.

(0000211)

Permit Term B **Purchase from Nevada Irrigation District**

When Used: Permits for storage on sources which could affect Nevada Irrigation District's water. (Also include standard permit terms 43 or 44 as appropriate).

Term: No water shall be diverted under this permit until permittee has installed devices, satisfactory to the State Water Resources Control Board, which are capable of measuring the flow into and out of permittee's reservoir during the nonstorage season unless water is purchased from the Nevada Irrigation District to offset seepage and evaporation losses at the reservoir. Said devices shall be properly maintained.

(000000B)

TERMS DIRECTLY REQUIRING MEASUREMENT (UNDERGROUND STORAGE AND RECOVERY)

Permit Term 117 **Measuring Devices – Underground Storage**

When Used: All permits for underground storage.

Term: Prior to diversion of water under this permit, permittee shall (1) install devices to measure the quantities of water placed into underground storage and (2) install devices to measure or provide documentation of the method to be used to determine the quantity of water recovered from underground storage and placed to beneficial use. All measuring devices and the method of determining the quantity of water recovered from underground storage shall be approved by the State Water Resources Control Board prior to diversion of water under this permit. All measuring devices shall be properly maintained.

(0080117)

TERMS DIRECTLY REQUIRING MEASUREMENT (LEVELS/STAFF GAGES)

Permit Term 47 **Measuring Devices – Reservoir Staff Gage(s)**

When Used: with Term 51 or other reservoir release requirements.

Term: Permittee shall install and properly maintain staff gage(s) in the reservoir(s), satisfactory to the State Water Resources Control Board, for the purpose of determining water levels in the reservoir(s).

Permittee shall record the staff gage readings on or about _____ * _____of each year. Such readings shall be supplied to the State Water Resources Control Board with the next progress report submitted to the Board by permittee.**

The State Water Resources Control Board may require the release of water that cannot be verified as having been collected to storage prior to October 1 of each year.

Permittee shall allow (name of protestant) and all successors in interest, or a designated representative, reasonable access to the reservoir(s) for the purpose of verifying staff gage readings *** and determining water levels in the reservoir(s).

(0070047) or (0100047)

*October 1, _____date_____ and ___date_____, or other date(s).

** Substitute specific dates for submitting the readings and/or add other parties to receive the readings as necessary.

*** Include only if verification of readings is required.

Permit Term D1 **Tributaries to Clear Lake – Agreement**

When Used: Storage projects when permittee has entered into the standard contract for purchase of water from Yolo County Flood Control and Water Conservation District.

Term: Permittee shall comply with the following provisions which are derived from the contract between _____ and Yolo County Flood Control and Water Conservation District executed on _____ and filed with the State Water Resources Control Board:

(1) If during the period from September 1 of any year through April 30 of the succeeding year, either (a) the elevation of Clear Lake has reached 7.56 feet as measured on the Rumsey Gage or (b) water has been discharged from Clear Lake to hold the water level down in compliance with the Gopcevic Decree, water collected to storage during permittee's corresponding diversion season shall be water appropriated under this permit. If during such period from September 1 through April 30, either (a) or (b) above does not occur, water collected in permittee's reservoir(s) shall be purchased from the Yolo County Flood Control and Water Conservation District.

(2) Permittee shall install and maintain in the reservoir(s) an accurate direct reading staff gage, calibrated to storage in acre-feet, which is referenced to a permanent benchmark. Permittee shall supply the staff gage reading on or about October 1 of each year to the Yolo County Flood Control and Water Conservation District and to the State Water Resources Control Board with permittee's report of annual water use.

(3) Permittee shall allow a designated representative of the Yolo County. Flood Control and Water Conservation District reasonable access to the reservoir(s) for the purpose of determining water levels.

Inclusion in this permit of certain provisions of the referenced contract shall not be construed as disapproval of other provisions of the contract or as affecting the enforceability, as between the parties, of such other provisions insofar as they are inconsistent with the terms of this permit.

(000000D1)

Note: If standard permit term 47 is to be included in the permit for other purposes, modify term 47 as in (2) and (3) above and delete those paragraphs from this term.

TERMS DIRECTLY REQUIRING MEASUREMENT (BYPASS FLOWS)

Permit Term 60 **Reservoir Stream Flow Bypass for Fish and Wildlife**

When Used: After agreement between applicant and Department of Fish & Game or if being imposed by the Board.

Term: For the protection of fish and wildlife, permittee shall during the period:

a. from through bypass a minimum of cubic feet per second,*

b. from through bypass a minimum of cubic feet per second,*

c. from through bypass a minimum of cubic feet per second.*

The total streamflow shall be bypassed whenever it is less than the designated amount.

The permittee shall submit a compliance plan, satisfactory to the Chief of the Division of Water Rights, which describes how the bypass flows required by the conditions of this permit will be measured and maintained.

(0140060)

* When appropriate, express in gallons per minute.

Permit Term 61 **Fish and Wildlife Bypass – Napa River**

When Used: All Napa River permits upstream from the City of Napa.

Term: For the protection of fish and wildlife, permittee shall during the period:

a. from June 1 through October 31 bypass a minimum of 3.0 cubic feet per second,

b. from November 1 through November 14 bypass a minimum of 1.0 cubic foot per second,

c. from November 15 through February 29 bypass a minimum of 15.0 cubic feet per second and,

d. from March 1 through May 31 bypass a minimum of 10.0 cubic feet per second.

The total streamflow shall be bypassed whenever it is less than the designated amount. Streamflows shall be as measured at the nearest USGS Gaging Station on the Napa River or by a device acceptable to the State Water Resources Control Board at alternative locations which may be designated by the watermaster administering the water distribution program.

(0140061)

* 3.0 cfs between Napa and Rutherford
  1.0 cfs upstream from Rutherford

Permit Term 62A **Measuring Device for Bypass Single – Project not Built**

When Used: If bypass of water is required.

Term: No water shall be diverted under this permit until permittee has installed a device, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flow required by the conditions of this permit. Said measuring device shall be properly maintained.

(0060062A)

Note: This term should not be used for the Russian River or other locations where permanent streamflow gages are reasonably near the point of diversion.

Permit Term 62AP **Measuring Devices for Bypass – Multiple Project not Built**

When Used: If bypass of water is required.

Term: No water shall be diverted under this permit until permittee has installed devices, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flows required by the conditions of this permit. Said measuring devices shall be properly maintained.

(0060062AP)

Note: This term should not be used for the Russian River or other locations where permanent streamflow gages are reasonably near the point of diversion.

Permit Term 62B **Measuring Device for Bypass – Single, Project Built**

When Used: If bypass of water is required.

Term: Permittee shall install a device, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flows required by the conditions of this permit. Said measuring device shall be properly maintained.

(0060062B)

Permit Term 62BP **Measuring Device for Bypass – Multiple, Project Built**

When Used: If bypass of water is required.

Term: Permittee shall install devices, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flows required by the conditions of this permit. Said measuring devices shall be properly maintained.

(0060062BP)

Note: This term should not be used for the Russian River or other locations where permanent streamflow gages are reasonably near the point of diversion.

Permit Term 70 **Flow Bypass Compliance Plan**

When Used: For projects with flow bypass permit terms.

Term: Within six months of the issuance of this permit, the Permittee shall submit a Compliance Plan for approval by the Chief of the Division of Water Rights that will demonstrate compliance with the flow bypass terms specified in this permit. The Compliance Plan shall include the following:

- A description of the physical facilities (i.e., outlet pipes, siphons, pipelines, bypass ditches, splitter boxes etc.) that will be constructed or have been constructed at the project site and will be used to bypass flow.
- A description of the gages and monitoring devices that will be installed or have been installed to measure stream flow and/or reservoir storage capacity.
- A time schedule for the installation of these facilities.
- A description of the frequency of data collection and the methods for recording bypass flows and storage levels.
- An operation and maintenance plan that will be used to maintain all facilities in good condition.

The Permittee shall be responsible for all costs associated with developing the Compliance Plan, and installing and maintaining all flow bypass and monitoring facilities described in the Compliance Plan.

The monitoring data shall be maintained by the permittee for ten years from the date of collection and made available to the Chief of the Division of Water Rights, upon request. Any non-compliance with the terms of the permit shall be reported by the permittee promptly to the Chief of the Division of Water Rights Diversion and use of water prior to approval of the Compliance Plan and the installation of facilities specified in the Compliance Plan is not authorized.

(0000070)

Permit Term 200 **Fish & Wildlife Protection Bypass Term**

When Used: Whenever a bypass term is needed for fish and wildlife protection and there is no special term for a stream system. Choose the most appropriate version to customize for each stream. Whenever possible, a passive bypass structure is usually preferable to a streamflow measuring device.

Term: a) For the protection of fishery resources, Permittee shall bypass a minimum of sixty percent (60%) of the average annual runoff of **stream name**, or **amount** cubic feet per second. The total streamflow shall be bypassed whenever it is less than the designated rate.

or

b) For the protection of fisheries, wildlife, and other instream (and public trust) uses in the **stream name,** diversions under this permit shall be subject to maintenance of minimum bypass flows in **stream name**:

1. From **date to date**, **amount** cubic feet per second;
2. From **date to date**, **amount** cubic feet per second;
3. From **date to date**, **amount** cubic feet per second;

for as many periods as necessary.

To be used with either a) or b) above: No diversion shall take place under this permit if the flow in **stream name** is, or would be reduced by such diversion, below the designated rates. To ensure compliance with this condition, by **date** of each year Permittee shall file a report with the Chief, Division of Water Rights, containing the following information:

a. Dates during the previous period of **date** to **date** when water was diverted under this permit; and
b. Flows measured in **stream name** under this permit during the same period.

a) No water shall be diverted under this permit until the Permittee has installed a structure in **stream name**, satisfactory to the State Water Resources Control Board, which is capable of passively bypassing the flow(s) required by the conditions of this permit. Permittee shall submit plans and specifications of the bypass structure to the Chief of the Division of Water Rights, within six-months of the date the permit is issued. The plans for bypass structure shall be reviewed and must be satisfactory to the Chief, Division of Water Rights, before any construction is undertaken. Permittee shall furnish evidence which sub-

stantiates that the bypass structure has been installed, within sixty (60) days from the date of approval of the water right permit. If the bypass structure is rendered inoperative for any reason, all diversions shall cease until such time as it is restored to service. Said bypass structure shall be properly calibrated, operated, and maintained by the Permittee (or successors-in-interest) as long as any water is being diverted under any permit or license issued pursuant to Application **NUMBER**.

or

b) No water shall be diverted under this permit until the Permittee has installed a device in **stream name**, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flow(s) required by the conditions of this permit. Permittee shall submit plans and specifications of the streamflow measuring device to the Chief of the Division of Water Rights, within six-months of the date the permit is issued. The device and the location of the monitoring station shall be reviewed and must be satisfactory to the Chief, Division of Water Rights, before any construction is undertaken. Permittee shall furnish evidence which substantiates that the streamflow measuring device has been installed, within sixty (60) days from the date of approval of the water right permit. If the measuring device is rendered inoperative for any reason, all diversions shall cease until such time as the device is restored to service. Said measuring device shall be properly calibrated, operated, and maintained by the Permittee (or successors-in-interest) as long as any water is being diverted under any permit or license issued pursuant to Application **NUMBER**.

(0140200)

Permit Term 201 **Pulse Flow Bypass Term for Coastal Streams**

When Used: For streams in the coastal mountain range with westerly drainage to the Pacific Ocean if there is no special term for the stream system and for use with Term 60.

Term: For the protection of anadromous fish attraction and migration in coastal streams, Permittee shall, during the diversion period from **months** be subject to maintenance of minimum bypass flows in **stream name**; except that the entire flow shall be bypassed for **number of** consecutive days after a Pacific storm causes streamflow in stream **name** to rise above **amount** cubic feet per second. Pulse flows shall be measured at **location**.

or

For the preservation of pulse flows, necessary for upstream migration of fish and gravel recruitment, the maximum rate of direct diversion or diversion to offstream storage shall not exceed **number** percent (%) of the average annual unimpaired flow of the **stream name**, or **amount** cubic feet per second.

To ensure compliance with this condition, by **date** of each year Permittee shall file a report with the Chief, Division of Water Rights, containing the following information:

a. Dates during the previous period of **date** to **date** when water was bypassed under this permit; and
b. Flows measured at **location** in **stream name** under this permit during the same period.

a) No water shall be diverted under this permit until the Permittee has installed a structure in **stream name**, satisfactory to the State Water Resources Control Board, which is capable of passively bypassing the flow(s) required by the conditions of this permit. Permittee shall submit plans and specifications of the bypass structure to the Chief, Division of Water Rights, within six-months of the date the permit is issued. The plans for bypass structure shall be reviewed and must be satisfactory to the Chief, Division of Water Rights, before any construction is undertaken. Permittee shall furnish evidence which substantiates that the bypass structure has been installed, within sixty (60) days from the date of approval of the water right permit. If the bypass structure is rendered inoperative for any reason, all diversions shall cease until such time as it is restored to service. Said bypass structure shall be properly calibrated, operated, and maintained by the Permittee (or successors-in-interest) as long as any water is being diverted under any permit or license issued pursuant to Application **NUMBER**.

or

b) No water shall be diverted under this permit until the Permittee has installed a device in **stream name**, satisfactory to the State Water Resources Control Board, which is capable of measuring the bypass flow(s) required by the conditions of

this permit. Permittee shall submit plans and specifications of the streamflow measuring device to the Chief, Division of Water Rights, within six-months of the date the permit is issued. The device and the location of the monitoring station shall be reviewed and must be satisfactory to the Chief, Division of Water Rights, before any construction is undertaken. Permittee shall furnish evidence which substantiates that the streamflow measuring device has been installed, within sixty (60) days from the date of approval of the water right permit. If the measuring device is rendered inoperative for any reason, all diversions shall cease until such time as the device is restored to service. Said measuring device shall be properly calibrated, operated, and maintained by the Permittee (or successors-in-interest) as long as any water is being diverted under any permit or license issued pursuant to Application **NUMBER**.

(0000201)

Permit Term 204 **Responsibility for Measuring Device for Bypass (if using a USGS-or DWR-Operated Gage)**

When Used: For all applications that have bypass specifications at stream gages operated by the USGS or Department of Water Resources.

Term: For the protection of fish and wildlife and instream uses, Permittee shall bypass the total streamflow, at all points of diversion, whenever the flow in the **stream name** is less than **amount** cubic feet per second as measured at the **name of gage** on **the stream name**, California. In the event that said gage is no longer available for streamflow measurements, Permittee (or successors-in-interest) is responsible for installing and maintaining an equivalent gage, satisfactory to the Chief, Division of Water Rights, as near as practicable to the present location of **name of gage**. In the absence of such an equivalent gage, all diversions must cease. These requirements shall remain in force as long as water is being diverted by Permittee (or successors-in-interest) under any permit or license issued pursuant to Application **NUMBER**.

(0000204)

Permit Term 211 (Term A) **Special Navarro River Terms**

When Used: For projects on the Navarro River (Terms A through D).

Term A: For the protection of fish and wildlife and instream uses, Permittee shall bypass the total streamflow, at all points of diversion, whenever the flow in the **stream name** is less than **amount** cubic feet per second as measured at the **gage** on the **stream name**, California. In the event that said gage is no longer available for streamflow measurements, Permittee is responsible for installing and maintaining an equivalent type gage, satisfactory to the Chief, Division of Water Rights, as near as practicable to the present location of **name of gage**.

(0000211)

Permit Term G **Fish Bypass on Lower Pescadero Creek or Butano Creek (San Mateo County)**

When Used: Permits on Lower Pescadero Creek or Butano Creek.

Term: The State Water Resources Control Board reserves jurisdiction over this permit to change the fish bypass amounts to conform to the results of a comprehensive field study to be completed by the California Department of Fish and Game to determine minimum streamflow required to protect fishlife. Action to change the bypass amounts will be taken only after notice to interested parties and opportunity for hearing.

No water shall be diverted under this permit until permittee has installed a device, satisfactory to the State Water Resource Control Board, which is capable of measuring the flows required by the conditions of this permit. Said measuring device shall be proper maintained. As an alternative, a single measuring device installed and maintained jointly by all water users on Lower Pescadero Creek (or Butano Creek*), located at a position on the creek acceptable to the Department of Fish and Game and the State Water Resources Control Board, may be substituted.

(000000G)

*Use only for permits on Butano Creek.

APPENDIX B: WATER USE MEASUREMENT AUTHORITIES

TERMS RESERVING/IDENTIFYING GENERAL AUTHORITY TO IMPOSE A VARIETY OF REQUIREMENTS

Permit Term 12 **Continuing Authority**

When Used: All permits.

Term: Pursuant to California Water code sections 100 and 275, and the common law public trust doctrine, all rights and privileges under this permit and under any license issued pursuant thereto, including method of diversion, method of use, and quantity of water diverted, are subject to the continuing authority of the State Water Resources Control Board in accordance with law and in the interest of the public welfare to protect public trust uses and to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of said water.

The continuing authority of the Board may be exercised by imposing specific requirements over and above those contained in this permit with a view to eliminating waste of water and to meeting the reasonable water requirements of permittee without unreasonable draft on the source. Permittee may be required to implement a water conservation plan, features of which may include but not necessarily limited to (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation.

The continuing authority of the Board also may be exercised by imposing further limitations on the diversion and use of water by the permittee in order to protect public trust uses. No action will be taken pursuant to this paragraph unless the Board determines, after notice to affected parties and opportunity for hearing, that such action is consistent with California Constitution article X, section 2; is consistent with the public interest; and is necessary to preserve or restore the uses protected by the public interest.

(0000012)

Forms
Statement of Water Diversion and Use
First Notice Groundwater Diversion

Complete a separate notice for each well.

State of California
State Water Resources Control Board

DIVISION OF WATER RIGHTS

P.O. Box 2000, Sacramento, CA 95812-2000

Info: (916) 657-2170, FAX: (916) 657-1485, Web: http://www.waterrights.ca.gov

Recordation Number

State Well Number

FIRST NOTICE
GROUNDWATER DIVERSION

(Pursuant to Part 5, Division 2 of the Water Code)

1. Name of person owning the well _____
(Unless otherwise indicated, annual notices will be sent to this name and address)

Address _____
Street address or P.O. Box number City State Zip Code

Telephone Number ( ) _____ - _____

2. Name of person extracting groundwater, if different than Item 1

Address _____
Street address or P.O. Box number City State Zip Code

Telephone Number ( ) _____ - _____

WELL LOCATION

3. Owner's designation of well _____ 4. County _____

5. County Assessor's Parcel Number _____

6. Describe location of well to the nearest 40-acre quarter section. State well number (if known) _____

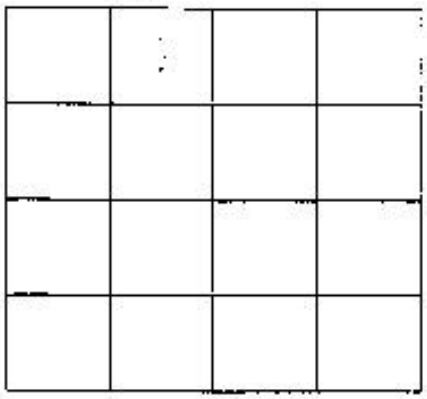
_____ ¼, of _____ ¼, Section _____, Township _____

Range _____, _____ B. & M.

7. Indicate location of well in the section grid below, or provide us with a copy of the USGS quadrangle map with the well location marked. The place of use should also be indicated. The grid represents one whole section.

Section _____, Township _____, Range _____

Quadrangle map name _____



GW-FIRST-EXTRC (1-09)

WATER USE

8. Describe the Place of Use: (If sketch is required, please use grid under item 7.) _____

9. Quantity and Use of water extracted and method used in determining quantity for the last calendar year.

Calendar Year	EXTRACTIONS		USE		
			When use is for irrigation		When use is other than irrigation
	Annual extractions in acre-feet or _____ (specify unit)	Method of measurement or of estimate (specify)	Crops served	Acreage Supplied	Name and nature of use, i.e. population, products manufactured, number and kind of stock watered
19					

10. Do you also divert surface water? _____ Yes or No

11. If answer (to 10 above) is yes, how are you reporting surface water use?

a. Under Statement of Water Diversion and Use procedures ☐
b. Under Annual Recordation Notice procedures ☐
c. Under Appropriative Water Right procedures ☐
d. Not reporting ☐

WELL DATA

12. Is place of use also served by another well? _____ Yes or No Another water source? _____ Yes or No

13. If yes to either, describe _____

14. Type, make and horsepower of pump _____ Date installed _____

15. Pump tests _____ Conducted by _____ Date _____ Discharge rate gpm _____ Pump efficiency

16. Power supply _____ Source _____ Motor No. _____ Date installed

17. Depth of well _____ feet. 18. Casing diameter _____ inches.

19. Is well gravel-packed? _____ Yes or No 20. Date drilled _____

21. What are the upper and lower depths of casing perforations? Upper _____ Lower _____ (Show feet from ground surface)

22. Is log of well available? _____ Yes or No Where? _____

23. Has a chemical analysis of well water been made? _____ Yes or No If yes, where can it be obtained? _____

24. Are water level measurements available? _____ Where? _____

PLEASE NOTE THAT:
A willful misstatement in this notice is a misdemeanor . . . Section 5008 of Water Code.
A $5.00 filing fee must accompany each notice.

I certify that the foregoing required statements and the following optional additional statements, if any, are true and correct to the best of my knowledge and belief.

Name _____

Signature _____

Title _____ **Date** _____

At (City of P.O.) _____

Firm or Corporate Name _____

GW-FIRST-EXTRT (1-00)

Cal/EPA

State Water Resources Control Board

Division of Water Rights

Pete Wilson
Governor

INSTRUCTIONS FOR FILING FIRST NOTICE GROUND WATER EXTRACTIONS

A SEPARATE FIRST NOTICE FOR EACH WELL should be typewritten or legibly written in ink. Where supplemental sheets are used, please make reference to the item number involved. Instructions for completing different ITEMS in the First Notice are as follows:

1. The person (or firm) in whose name the notice is to be recorded should be stated here. Please use the same name for all wells.

2. Names of persons not included in Item 1 who are known to be using the well or claim an interest in water extracted therefrom should be listed in this item or on a supplemental sheet. It is not necessary to include names of persons if the extractor is a mutual water company, public utility or public agency.

3. The owner's designation by number and/or name may be given in this item in order to properly identify the well referred to in the notice. If this is the only well, it will suffice to insert "No. 1" in this item.

4. It is important to state the COUNTY in which the well is located. This determines the first two numbers of the recordation number.

5. The County ASSESSOR'S PARCEL NUMBER is important and must be included.

6. The description of the well location should be sufficiently clear to enable a stranger to find it on the ground or to locate it on a map of the area. The description may be made on the grid in Item 6. Post Office Box or Rural Route Numbers are NOT ACCEPTABLE.

7. The complete grid represents one section. The township, range, and section number is necessary for the computer program to accept the data. The quadrangle map name is shown in the lower right hand corner of the USGS map.

8. If the water is used on an area within one mile of the well a statement to that effect will suffice, otherwise a description or sketch of the general area of use must be given. It is preferred that the United States public land survey system of Township, Range, Section, and portion thereof be used to describe the area of use. If a sketch is drawn in lieu of such description it should outline the area served with the distances clearly shown to roads or other prominent landmarks which may be easily located. A mutual water company, public utility or public agency may attach a map outlining the general service area. In this regard, submission of one copy of a map delineating the service area for several wells will be sufficient.

Recycled Paper

Our mission is to preserve and enhance the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

WR 1061 4/94

FIRST NOTICE OF
GROUNDWATER EXTRACTIONS

-2-

9. The total amount of water extracted must be reported in this item. It is preferable to report the amount in acre-feet, but it may also be reported in cubic feet or gallons. The unit of measurement used must be noted in the space provided. If the amount of water extracted was estimated rather than being measured by a meter, weir, volumetric, or any other direct measuring device, the method by which the quantity was estimated should be specified, such as depth of applied water and acreage served, power records, lift and pump test, or other. (1 acre-foot = 43,560 cubic feet = 325,851 U.S. gallons).

The use of water extracted should be indicated by giving total acreage of each crop served. If more than one kind of crop is served by water from the well, list separately the number of acres under each crop. If use is for purposes other than irrigation the the amount of the use should be indicated. For example, the water may be used for domestic purposes for 20 persons and 6 residences, and stockwatering for 200 head of cattle. (If more space is needed the information may be entered on another sheet of paper and attached to this notice).

10. through 14.
Information supplied under these items will tend to support the claim of right to the use of ground water and will assist in reducing the cost of verification of the data contained in the notice in the case where such verification is requested under Water Code Section 5007.

EACH NOTICE MUST BE SIGNED, DATED, AND SUBMITTED WITH THE REQUIRED FILING FEE TO:

State Water Resources Control Board
Division of Water Rights
Post Office Box 2000
Sacramento, CA 95812-2000

APPENDIX C:
MEASUREMENT IN SELECTED STATES

SUMMARY

To round out the institutional picture, the Technical Team supplemented its review of California policy and regulation with a look at measurement in six other selected states. Generally speaking, the picture of measurement presented below indicates that other states have been and are actively engaged with the issue of agricultural water use measurement in a serious fashion. The mechanisms that they use are somewhat different in each case. Drawing from the six collectively, one can summarize some of the elements of a measurement program as follows:

- Typically there is a required minimum degree of accuracy for measurement devices and methods.
- There may also be a required method for validating or certifying measurement devices and methods as meeting the accuracy requirement.
- A variety of variances and exemptions from various requirements are typically provided for.
- It is may be helpful to distinguish between various elements of the program. For example, after installation of methods and devices, states may vary in whether measurements are reported by water users or by agency staff (e.g., agency-employed watermasters). Depending upon desired program design, the following duties or rights may be allocated in a variety of ways amongst users, agency staff or others:
  - the duty to construct or install the measuring device or method;
  - the duty to calibrate and maintain the equipment;
  - the duty to read and record measurements;
  - the duty to confirm degree of accuracy of measurement methods and devices;
  - the duty to confirm degree of accuracy of the calibration of methods and devices;
  - the duty to maintain measurement records;
  - the duty to report measurements;
  - the duty to store and manage reported data;
  - the duty to compile data;
  - the duty to track and verify individual compliance with measurement and reporting obligations;
  - the duty to perform quality assurance on compiled data;
  - the duty to summarize and present compiled data in reports or plans; and
  - the right of access to data.
- There appears to be a direct relationship between the number of physical locations at which measurement is required and the needed agency staffing levels.

BACKGROUND AND PURPOSE

The purpose of this section is to describe existing legal rules and programs pertaining to measurement of water use in selected states other than California. The information is summarized below in two forms: (1) a table; and (2) a narrative summary. The purpose of the table is to summarize the information from the narrative and to provide a tool for creating comparisons across states.

This information was prepared at the recommendation of the Panel based upon its June 2001 meeting. The information collected is intended to facilitate Panel and technical teamwork in identifying various possible approaches for measurement of agricultural water use in California.

Collectively, the states consulted provide potentially helpful models and approaches for the Panel to consider. Individually, however, it appears that no single state consulted

provides a perfect ideal for California to follow. For example, California is not principally dependent upon groundwater, and not substantially free of extensive government-owned conveyance facilities. Thus, rather than attempting to pick one state and duplicate its approach to measurement, it is recommended that readers regard the whole of the summary as providing background and potential ideas for formulating measurement approaches in California.

RESEARCH METHOD

This information was developed through a review of statutes, regulations, agency guidance documents, internal agency memoranda, and other documents describing measurement programs in other states. In addition to a review of documents, agency staff in the six featured states were interviewed by telephone.

The interviews were open-ended and qualitative, and generally occurred following the interviewer's review of statutes and other main documents. Drawing on the review of state documents, the interviewer verbally confirmed major understandings and impressions regarding the workings and emphases of the subject state's programs. In particular, the interviews focused on the following questions, which were previously developed in conjunction with the Panel's June 2001 meeting:

- Who requires or provides incentives for water use measurement?
- Who measures water use? Where and how?
- Who compiles, stores, distributes and uses measurement information and how?
- What are the purposes, benefits, and problems of the approach taken in your state?
- Does actual practice live up to the intended policy incentives or legal requirements?

In addition, interviewees were asked the following questions:

- What are the most important states to look at as examples?
- Who should we talk to?
- What helpful documents already exist? For example, has your state prepared any cost-benefit analyses regarding implementation of a measurement program or individual measurement requirements?

The sample of six states is not meant to be an attempt at a statistically representative sample. The sample of states presented here was developed opportunistically, after narrowing the field with some broad criteria. It was thought that western states would provide the best starting point for research. Also, it was thought that the sample should include both coastal states and states with some focus on groundwater. Some Panel members also suggested that particular states should be toward the top of the list of those consulted.

Initial attempts were made to identify key agency personnel with oversight responsibility for measurement programs in a number of states. When the agency personnel were eventually interviewed and asked which other states should be consulted, in several instances they named one or more of the states already on the priority list. After six states had been surveyed in this way, it was felt that a variety of approaches to measurement had been represented, and that any further review of additional states should be done if it were thought that a particular missing state's program might add something helpful to the overall picture.

Persons interviewed for the summaries below were from state agencies that oversaw state water management, administration of the state's water rights system, or both. All appeared to be experts in regard to their own programs, and all had direct managerial responsibility for measurement-related programs within their agencies, or had more senior managerial oversight of broader areas of agency function.

Table 3.1 summarizes the technical team's findings for six important/relevant states: Kansas, Oregon, Washington, Arizona, Colorado, Idaho. For each state, we summarize our findings as follows:

- What are the Purposes of Measurement Program?
- Who requires or provides incentives for measurement?
- What is the mechanism for imposing measurement requirements on particular users or groups of users?
- How is the manner in which measurement must occur specified When required, where must measurement devices be located? Reporting and data management.
- Issues (Problems, Constraints, Benefits)
- Theory vs. Practice

NARRATIVE SUMMARY: ARIZONA

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

There are no specific statewide standards or requirements pertaining to measurement of surface water use, with the exception of areas subject to active decrees. In Arizona, such areas include the Little Colorado River and Gila River systems. These areas, which include most of the state's surface rights, are subject to longtime decrees and are also presently undergoing general adjudications in the courts. Under the decrees, the courts have typically required users to measure and report diversions from natural streams into canals using weirs. It is anticipated that the results of the present adjudications will also include some form of measurement and reporting requirements. The Bureau of Reclamation also requires measurement of diversions from the Colorado River mainstem.

In 1980, the legislature passed the state Groundwater Management Code, and established the Arizona Department of Water Resources to administer the code. The Code establishes three levels of water management to respond to different groundwater conditions. The lowest level of management includes general provisions that apply statewide. The next level applies to Irrigation Non-Expansion Areas (INAs). Areas where groundwater depletion is most severe are designated as Active Management Areas (AMAs). The boundaries of INAs and AMAs are generally defined by groundwater basins, not political boundaries. Three INAs and five AMAs have been designated. The Department must prepare a series of five management plans for each AMA.

The Groundwater Management Code prohibits new irrigated acres within AMAs and INAs.

Rightholders who pump groundwater from wells with maximum pump capacity greater than 35 gallons per minute in an AMA must measure those withdrawals using an approved measuring device or method. Such rightholders must also report annual water withdrawal and use to the Department. The reports must be audited. Within an AMA, the report must be filed even if no water was pumped. Within an INA, only those who actually pumped water must submit a report.

Such rightholders also pay an annual groundwater withdrawal fee, which is used to offset half the cost of administering the Groundwater Management Code, with the other half coming from the state's general fund. Withdrawal fees can also be used for conservation assistance and augmentation projects such as groundwater recharge, as well as retirement of irrigated land. The fee can vary from year to year but does not exceed five dollars per acre-foot of groundwater withdrawn.

WHO MEASURES WATER USE?

Small properties (under 10 acres) are exempt from measurement requirements. Persons who use only surface water not subject to any decree are also exempt from measurement requirements.

Under Department regulations, measurement is to be conducted by any "responsible party" which is defined as "an irrigation district or a person required by A.R.S. Title 45 or by a permit, rule, or order issued pursuant to A.R.S. Title 45, to use a measuring device or method approved by the Director." (Arizona Administrative Code, § R12-15-901 (5).) More specifically, the regulations state that a "responsible party shall install an approved measuring device to monitor the volume of water withdrawn, delivered, transported, recharged, stored, replenished, recovered, and used." (Arizona Administrative Code, § R12-15-902 (A).) In general, there need not be a separate measuring device for each right, unless specifically required in a particular case, but the number of measuring devices must be sufficient to allow for separate monitoring and reporting of volumes for five types of rights: 1. irrigation grandfathered rights; 2. non-irrigation grandfathered rights; 3. service area rights; 4. groundwater withdrawal permits; and 5. recovery well permits or water storage permits. (Arizona Administrative Code, § R12-15-902 (B).)

WHERE AND HOW IS WATER USE MEASURED?

Approved measuring devices must be installed as close as possible to the wellhead, point of delivery, receipt, transportation, recharge, storage, replenishment, recovery, or use which the device is intended to measure, consistent with the manufacturer's instructions. (Arizona Administrative Code, § R12-15-902 (C).) The state requires that measurement be at both the point of pumping and the point of delivery to the farmer. The pumping is often done collectively, through a district. The state has learned that there is almost no way to get accurate measurement at the property boundary. Thus, they use the turnout instead, which is typically at the high point of 160 acres. To estimate measurement at the point of delivery to each right, the user provides an estimate based on pro rata share of the acres irrigated, or based on acres irrigated plus consumptive use of each crop grown.

Persons required to measure must use an "approved" measuring device with an approved measuring "method." The Department formerly maintained a list of water measuring devices that meet the accuracy requirement of ± 10%. (Arizona Administrative Code, § R12=15-905 (A).) The Department later abandoned the list approach, however. It proved too burdensome to keep up with technology, maintain the list and respond to requests to add things to the list (and complaints about things the Department had included). Now

APPENDIX C: MEASUREMENT IN SELECTED STATES

TABLE C1. SUMMARY OF MEASUREMENT IN SELECTED STATES

State	Purposes of Measurement Program
Arizona	• Providing data for budgets of water use and trends, as well as flow models. • Providing information for compliance work, to ensure that persons take no more water than they are rightfully entitled to (including as an input to calculations of exceedances under the state "flexibility account" system). • Helping farmers to accurately know at what point to stop applying water based on crop-specific irrigation needs. • Computing the amount of tax owed by each groundwater user.
Colorado	• Monitoring water use to ensure that it is in accordance with water rights. • Limiting waste of water. • Improving water management. • Providing water right owners with an official record that can be certified to the courts, providing a basis for proving historic use in a change of water right case or sale of water right. • Helping Colorado to meet interstate compact requirements.
Idaho	• Helping in enforcement against excessive use. • Helping to ensure delivery of the correct amounts by the watermaster. • Protection of the users' rights in adjudications and transfers by reliably documenting various uses. • Ensuring and demonstrating compliance with interstate compact requirements. • Contributing to planning and scientific work relating to statewide water resource management.
Kansas	• The principal purpose of the measurement effort is "water management." Measurement information is used to revise standards for what is a "reasonable" maximum use of water for particular types of beneficial uses. Those maximum amounts are used in all new permits. After perfection, the right is limited to actual demonstrated reasonable and beneficial use. • Other stated purposes include effective administration of water rights to prevent impairment, to protect minimum desirable stream flows, to conserve water, or to otherwise carry out the duties of the chief engineer as set forth in statutes.
Oregon	• Increasing user awareness of the amount of water they use to improve self-regulation and business operations and plans. • Providing reliable evidence for water right holders to rebut allegations of forfeiture for non-use. • Assisting watermasters in the effective distribution of water in accordance with the rights of record. • Providing accurate information to help with in-stream flow monitoring, streamflow restoration projects, or improved water distribution efforts for fish and habitat. • Refining and updating the water availability model, which is used to evaluate whether new water right permits may be issued. • Providing information demonstrating actual use as evidence for water right certification. • Supporting injury/no-injury determinations for proposed water right transfers, permit amendments, exchanges and voluntary in-stream leases. • Supporting decision-making for projects to conserve water under the Allocation of Conserved Water program under which users may keep some of the water that they conserve. • Supporting agency actions to regulate use for the protection of senior water rights. • Acting as an early warning system for catastrophic flood events. • Helping to coordinate water release schedules for stored water. • Helping to monitor the status of critical ground water areas.
Washington	• Maintenance of adequate in-stream flows for protection of salmonid habitat. • Verifying water rights compliance. • Providing a basis for curtailing diversions in excess of authorized water rights in order to make more water available for aquatic habitat. • Determining the availability of water for further appropriation. • Identifying opportunities for more efficient water use. • Conducting any needed hydrologic studies.

Who requires or provides incentives for measurement?		
Judges, by decree (adjudications)	**Legislature, by statute requiring measurement**	**Statute gives agency discretion to require measurement of water use**
Yes	———	• Statute gives agency discretion to require measurement of water use. • By ground water right holders who pump groundwater from wells with maximum pump capacity greater than 35 gallons per minute within a designated Active Management Area on a land area greater than 10 acres. • (Statute also provides for a usage-based fee on groundwater water withdrawal/diversion to cover half the cost of the program with the other half coming from the state's general fund. Withdrawal fees can also be used for conservation assistance and augmentation projects such as groundwater recharge, as well as retirement of irrigated land.)
Yes	• By owner of any irrigation ditch, canal, flume, or reservoir in the state taking water from any stream, at point of intake. • By owners of any irrigation ditch, canal, or reservoir, transferring water from one natural stream to another, or from a reservoir, ditch, or flume to a stream for diversion. • By owners of any reservoir in the bed of any natural stream or through which any natural stream flows, in the bed and channel of every natural stream or watercourse discharging waters into said reservoir. • Anyone transferring water from one public stream to another, at the point where the water leaves its natural watershed and is turned into another and also at the point where it is finally diverted for use from the public stream. • Where the owner of a reservoir delivers stored water into a ditch or into the public stream and takes in exchange water from the public stream higher up. • (Statute also allows agency to require access to records of energy used for pumping.) • (Statute also allows groundwater management districts to impose measurement requirements.)	• By any owner or user of a water right.
Yes	———	• By all water users within a water measurement district, where the agency forms such a district. • Statute allows users to form "ground water district" to promulgate their own measurement, recharge and mitigation plans where state has already imposed measurement requirement by formation of a "water measurement district."
Yes	———	• By any water user.
Yes	• By all governmental entities who hold a water right.	• By any holder of a water right permit (permits "shall set forth any terms, limitations and conditions as the department considers appropriate"). • By owner of any ditch or canal. • By "affected water right holders" where the Commission adopts a rule to designate an area as having "serious water management problems." • By appropriators or users of any public waters of state. • (Statute also allows agency to provide a funding match of monies needed for installation and maintenance of measurement devices (currently unfunded).)
Yes	• By any owner of any water diversion. • Agency enforcement is required in fewer circumstances than those in which measurement is required.	• By persons obtaining new ground water rights permits.

TABLE C1. SUMMARY OF MEASUREMENT IN SELECTED STATES, CONTINUED

State	What is the mechanism for imposing measurement requirements on particular users or groups of users?	How is the manner in which measurement must occur specified?	When required, where must measurement devices be located?
Arizona	• Statute establishes three levels of water management (including measurement) to respond to different groundwater conditions. • The agency assigns these designations to particular areas.	• By regulations that specify methods and performance standards but not particular devices. The Agency now just relies on standards, having abandoned the approach of listing specific devices as being too burdensome administratively.	• Regulations require that approved measuring devices must be installed as close as possible to the wellhead, point of delivery, receipt, transportation, recharge, storage, replenishment, recovery, or use which the device is intended to measure, consistent with the manufacturer's instructions, and requiring measurement be at both the point of pumping and the point of turnout to delivery to the farmer (not the property line). • At point of intake of any irrigation ditch, canal, flume, or reservoir taking water from any stream.
Colorado	• By Statute. • By administrative order (applied to an individual or to an area).	• By Agency orders/rules subjecting particular geographic regions to measurement requirements and specifying the approach. In the Arkansas River Basin groundwater wells are required to be metered with totalizing flow meters or rated to determine a power coefficient (due to results of litigation over interstate compact compliance).	• At point where transferred water leaves its natural watershed and point of final diversion for use from public stream. • At certain other locations such that specified types of flows may be "definitely ascertained and determined.
Idaho	• By agency creation of "water districts" (where rights have been adjudicated) or "water measurement districts" (where there has been no adjudication but the agency believes measurement should be required).	• Agency lists or guidelines that are referenced in regulations and identify acceptable methods or devices	• At point of diversion.
Kansas	• By conditions in water rights permits.	• Very strong emphasis in the regulations on manufacturer demonstration of quality assurance, as well as proper installation and maintenance. Agency lists or guidelines that are referenced in regulations and identify acceptable methods or devices.	• All nondomestic, nontemporary wells, pumpsites and gravity diversions.
Oregon	• By conditions in water rights permits triggered at issuance for large diversions or upon posting of a "headgate notice" for smaller diversions. • By administrative rule (applied to an area with "serious water management problems"; never used so far).	• Regulations that specify methods and performance standards but not particular devices.	• At such points as may be necessary.
Washington	• By statute. • By conditions in water rights permits.	• Regulations that specify methods and performance standards but not particular devices.	———

Reporting and Data Management	Issues (Problems, Constraints, Benefits)	Theory vs. Practice
• Distinct reporting forms/worksheets are required for different measurement methods and devices.	• Referred to number of points at which measurement is required as increasing the staffing burden. (e.g., more individual rightholders more burdensome than measurement by collectives). • Referred to burdens of adopting a paper-heavy approach compared with accountability benefits of creating an audit trail. • Referred to fact that groundwater measurement equipment breaks down and farmers do not promptly check and repair, leading agency to prefer power consumption coefficient method.	———
• User's duty to construct and maintain measurement and control devices is distinguished from Agency's duty to supervise and control the devices and to record and report measurements.	• Referred to staffing levels as limiting the number of points at which measurement can be required; current staffing level is adequate for the number of surface diversions, but limits the agency's ability to expand the program to cover the more numerous groundwater wells statewide.	———
• Requires reporting of maximum instantaneous flow rate and annual total volume. • By watermasters in water districts, "district hydrographers" in water measurement districts.	• Referred to staffing levels as limiting the agency's ability to perform adequate data quality assurance. • Referred to generally incompatible desires of numerous types of people for measurement that is simultaneously as inexpensive as possible and as accurate as possible. • Some lack of consensus/focus in the state regarding what is the purpose of the data being collected, and what will it be used for.	• Measurement has not induced much conservation because the "flexibility account" system has generally allowed farmers to build up huge credits reducing the incentive for conservation.
• Initially, the Division of Water Resources (which handles water rights issues) enforces the measurement and annual reporting requirement and enters the data into the computer system. The Kansas Water Office (which is the state's water planning agency) then compares the data to existing standards and makes sure the data is consistent with known typical water uses for various beneficial uses. The agencies follow up together in contacting users of atypical amounts to clarify the numbers. The "cleaned up" data is then included in the final database used for planning and other purposes.	• Referred to strong emphasis in regulations on manufacturer certification, installation, and maintenance as removing poor products from market, and increasing quality of data and straightforwardness of agency task in using data.	———
———	• Referred to staffing levels as limiting the agency's ability to perform adequate data quality assurance.	• Where measurement is required by permit condition, they have less than a 50% compliance rate.
• Require reporting of maximum instantaneous flow rate and annual total volume. • Required frequency of recording increases with size of diversion.	• Referred to staffing levels as limiting the number of points at which measurement can be enforced.	• A lawsuit successfully challenged the agency for failure to properly implement statute.

the Department just relies upon the performance standard.

To be approved, a device must also be installed, maintained, and used in accordance with the manufacturer's recommendations. (Arizona Administrative Code, § R12-15-903.)

Approved methods include: (1) totalizing measuring method; (2) electrical consumption measuring method; (3) natural gas consumption measuring method; (4) hour meter measuring method; (5) elapsed time of flow method. (Arizona Administrative Code, § R12-15-903.) Responsible parties can use alternative water measuring devices or methods if approved in advance by the Department, which the Department shall approve if they meet the accuracy requirements. (Arizona Administrative Code, § R12-15-909.)

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

There are six different types of worksheets that must be completed and submitted to the Department by extracters of groundwater from wells within AMAs with capacities greater than 35 gallons per minute. The choice of worksheet depends on the type of meter or method used to calculate the volume of water pumped. Details of these reporting requirements are set forth in Arizona Administrative Code, section R12-15-904. The Arizona approach is relatively "paper heavy" compared with some other states, such as Kansas. The advantage of the worksheet approach is that it helps create an audit trail.

The data from the worksheets/reports is coded into the computer and yields an ability to identify well-by-well pumpage. There is an accuracy requirement for the reports, which is distinct from the accuracy requirement for the devices. The reporting standard gets tougher over time. Violations cannot be found unless the amount withdrawn exceeds the amount reported by 15% through 1989, 10% through 1999, and 8% through 2009. (Arizona Administrative Code, § R12-15-1003.)

The reported data are used in planning efforts, including the preparation of budgets of water use and trends, as well as flow models. The data are also used in compliance work, to ensure that persons take no more water than they are rightfully entitled to. Also, the data is used in computing the amount of tax owed by each groundwater user.

In a compliance mode, measurement information is used to calculate exceedances of amounts allowed through the state's system of "flexibility accounts." In AMAs, the limit of a person's rights to use groundwater is determined through a process involving a number of factors. First, the only lands that can be irrigated are lands that were legally irrigated between 1975 and 1979. For example, these so-called "irrigation acres" would be 1,000 acres for a farmer who owned 1,000 acres and irrigated all of them, 250 acres at a time, in a four year rotation. The "water duty acres" are the highest number of acres irrigated at any time between 1975 and 1979. Thus, if the same farmer irrigated every acre at least once during the relevant 5 years, his irrigation acres would be 1,000, and if he irrigated 500 of them in one of those years, his "water duty acres" would be 500. The "water duty" is the amount of water per year, expressed in acre-feet, reasonably necessary to irrigate the crops historically grown on a given farm. Deriving the "water duty" involves an exercise in judgment, an understanding of crop irrigation needs, and a knowledge of what "reasonable conservation methods" are available to users. For each AMA, there are supposed to be five plans of ten years duration each. From plan to plan, the water duty tightens up in order to induce greater conservation, until the mid-point in the process, in plan 3, when the plans call for maximum efficiency.

Multiplying the "water duty acres" by the "water duty" produces the number of acre feet in the "maximum annual groundwater allotment."

Users are not limited to their annual allotment. Rather, the amounts they use above and below the allotment go into a so-called "flexibility account" as debits and credits. The Department maintains such an account for each farm. In any given year, a user can use up to all of the credits accumulated in his or her account. Where those credits are insufficient, a farmer can borrow up to 50% of the maximum annual groundwater allotment. Thus, the Department would not deem a farmer to be out of compliance until the farmer was using more than 150% of the maximum annual groundwater allotment. Measurement of actual water use plays a role in this compliance/enforcement step, but does not play a significant role in the calculation of the allotment (with the exception of some historical data used to identify average irrigation use in the late 1970s).

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

The two main purposes are to enforce water rights, and encourage conservation. In terms of operational changes that produce conservation, one staff person frames the goal as follows: to help farmers accurately know at what point to stop applying water. To fulfill this goal, one should understand: (1) when to irrigate, (2) how much to irrigate for a particular crop, and (3) when one has reached that point and should stop.

The primary management goal for the AMAs is safe yield by the year 2025. In the Santa Cruz AMA, where significant international, riparian and groundwater/surface water issues exist, the goal is to maintain safe yield and to prevent local water tables from experiencing long term declines. In the Pinal AMA,

where a predominantly agricultural economy exists, the goal is to allow the development of non-irrigation water uses, extend the life of the agricultural economy for as long as feasible, and preserve water supplies for future non-agricultural uses.

The management goal in INAs is to prohibit the expansion of acreage irrigated with groundwater. The Groundwater Management Code restricts irrigation to land that was irrigated in the five years prior to an area's designation as an INA.

The administrative burden on the agency has not been very unreasonable regarding wells, one staff person reports. Regarding individual users/rightholders, however, the agency confronted substantially larger costs.

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

According to one staff person, "Theory and practice have been very far apart." There has been significantly less use than provided for in the allotments. As a result, farmers have built up huge numbers of credits in their flexibility accounts. This has substantially limited the incentive for conservation derived from the planning process.

The main rule that drives conservation has instead been the rule that, for every additional acre-foot of surface water used, groundwater must decrease by one acre-foot. In other words, as long as one pumps some groundwater, one's maximum annual allotment is calculated in such a way that substitute supplies cannot be added to one's pumping. This serves the policy goal of decreasing the burdens on the groundwater system. The only way to escape this rule is to use no groundwater at all, which would take one's use outside of the measurement and reporting requirements altogether.

One staff person reports that the agency prefers the electric consumption method of measuring. Water meters break down and the farmers do not check them or repair them. Whereas electricity meters almost never break, and the power company collects the data. If an electricity meter works, he says, it is usually within ± 2% in accuracy.

NARRATIVE SUMMARY: COLORADO

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

The state legislature has enacted statutes providing for measurement of surface and groundwater. The state Division of Water Resources (also known as the Office of the State Engineer) implements these statutes. State law gives general authority to the Division of Water Resources to administer, distribute and regulate the waters of the state. (Colorado Revised Statutes, § 37-92-501 ("CRS").)

WHO MEASURES WATER USE?

ANY OWNER OR USER OF A WATER RIGHT MAY BE REQUIRED BY ADMINISTRATIVE ORDER TO MEASURE WATER USE

Under state law, the Division of Water Resources has a set of general authorities to require measurement by means of administrative order. The State Engineer is authorized to order any owner or user of a water right to install and maintain at the owner's or user's expense necessary meters, gauges, or other measuring devices and to report at reasonable times to the appropriate Division Engineer the readings of such meters, gauges or other measuring devices. (CRS, § 37-92-502, subd. (5).)

Also, the "state engineer and the division engineers have authority to order any person or company supplying energy used to pump ground water to provide, at reasonable times to the appropriate division engineer, records of energy used to pump ground water." (CRS, § 37-92-502, subd. (5)(a) & (b).)

MEASUREMENT IS REQUIRED BY STATUTE AT SPECIFIC POINTS IN THE SYSTEM: SURFACE WATER

In regard to surface water, state law distinguishes between the duty to construct and maintain and the duty to supervise and control a measurement device.

<u>The Duty to Construct and Maintain</u>

The duty to construct and maintain measuring devices falls on several different categories of people.

- "The owners of any irrigation ditch, canal, flume, or reservoir in this state, *taking water from any stream*, shall erect where necessary and maintain in good repair, at the point of intake of such ditch, canal, flume, or reservoir, a suitable and proper headgate of height and strength and with embankments sufficient to control the water at all ordinary stages *and suitable and proper measuring flumes, weirs, and devices* and shall also erect and maintain in good repair suitable wastegates where necessary in connection with such ditch, canal, flume, or reservoir intake." (CRS, § 37-84-112, subd. (1) (emphasis added).)

- "The owners of any irrigation ditch, canal, or reservoir, transferring water from one natural stream to another, or from a reservoir, ditch, or flume to a stream in order that said water may be diverted from such stream for irrigation or any other purpose, shall construct suitable and proper measuring flumes or weirs, equipped with self-registering devices if required by the state engineer, for the proper and accurate deter-

mination of the amount and flow of water turned into, carried through, and diverted out of said natural stream." (CRS, § 37-84-113 (emphasis added).)

- "The owners of any reservoir *situate upon or in the bed of any natural stream or through which any natural stream flows, for the purpose of storing or diverting water* …at the expense of such owners and under the supervision and with the approval of the state engineer, shall construct and permanently maintain a suitable and permanent measuring weir or flume equipped with self-registering devices, according to plans and specifications approved by the state engineer, in the bed and channel of every natural stream or watercourse discharging waters into said reservoir by means of which all of the water flowing into said reservoir from and through each such stream or watercourse, at all times may be definitely ascertained and determined." (CRS, § 37-84-117 (emphasis added).)

- In regard to water transfers, anyone "*transferring water from one public stream to another* is required to construct and maintain, under the direction of the state engineer, measuring flumes or weirs and self-registering devices at the point where the water leaves its natural watershed and is turned into another and also at the point where it is finally diverted for use from the public stream." (CRS, § 37-83-102 (emphasis added).)

- Similar requirements are imposed where the owner of a reservoir *delivers stored water into a ditch or into the public stream and takes in exchange water from the public stream higher up.* (CRS, § 37-83-104.)

The Duty to Rate

Officials from the Division are required to "rate" the measuring flumes and weirs. (CRS, § 37-84-114.) When they are trying to rate a weir, or flume, or measuring section of a canal, it is a misdemeanor for the diverter to fail to adjust flow to enable that rating. (CRS, § 37-80-11.)

The Duty of Supervision and Control

"All headgates, measuring weirs, flumes, and devices used in connection with canals, flumes, and ditches or reservoirs for the measuring and delivering of waters therefrom and thereto shall be under the supervision and control at all times of the state engineer and the division engineer of the water division wherein such headgates, measuring weirs, flumes, and devices are located." Any water user is allowed to read any gauge, gauge rod, or measuring device or determine the quantity of water diverted by any canal or impounded in or delivered from any reservoir. (CRS, § 37-84-116.)

The allocation to the government of authority to supervise and control the measurement device is counterbalanced by the threat of criminal sanctions against the responsible official. "Any division engineer, or his deputy or assistant, who willfully neglects or refuses, after being called upon, to promptly measure water from the stream or other source of supply into the irrigating canals or ditches, in his division, according to their respective priorities, to the extent to which water may be actually necessary for the irrigation of lands under such canals or ditches, is guilty of a misdemeanor and, upon conviction thereof, shall be subject to [a penalty set forth in statute]." (CRS, § 37-84-122.)

MEASUREMENT IS REQUIRED BY STATUTE AT SPECIFIC POINTS IN THE SYSTEM: GROUND WATER

State law allows for the formation of groundwater management districts, whose boards of directors are authorized to impose controls or regulations after consultation with users and the state Ground Water Commission. (CRS, § 37-90-131.) The control measures and regulations can include provisions "to prescribe satisfactory and economical measuring methods for the measurement of water levels in and the amount of water withdrawn from wells and to require reports to be made at the end of each pumping season showing the date and water level at the beginning of the pumping season, the date and water level at the end of the pumping season, and any period of more than thirty days cessation of pumping during such pumping season." (CRS, § 37-90-131.)

MEASUREMENT IS REQUIRED BY STATUTE AT SPECIFIC POINTS IN THE SYSTEM: OTHER

There is no statutory requirement that deliveries by diverters to farms within water districts be reported. As to measurement at turnouts to individual users, "It is the duty of those owning or controlling [of any canal or ditch used for irrigating purposes] to appoint a superintendent, whose duty it is to measure the water from such canal or ditch through the outlets to those entitled thereto, each according to his pro rata share." (CRS, § 37-84-120.) Numerous districts measure such deliveries anyway for billing purposes. Some districts are more lax in measuring deliveries, using merely flow "time" as an indirect or surrogate measure for actual volumes delivered.

WHERE AND HOW IS WATER USE MEASURED?

Water use is measured at the locations described above.

Sometimes the Division itself measures flows at a point where tailwater returns to the public stream. This is done in order to identify areas where steps might need to be taken to

curb excessive extraction or tailwater. More typically, this determination is made based on just visual inspection of the tailwater flows. That is, measurement or visual inspection at the point of return flow to the water source is used to flag promising areas for further inquiry as to conservation potential.

The state consists of numerous water basins. For measurement purposes several basins along the western side of the state are clustered together into the Colorado River region, such that the entire state is conceptualized as four regions: (1) the Colorado River region; (2) the Rio Grande region; (3) the South Platte region; and (4) the Arkansas region.

Groundwater measurement requirements vary by region. In the Colorado River region, there is no significant groundwater, and accordingly no requirement for measurement. The Rio Grande region has three major aquifers. There, groundwater withdrawals are estimated, but no actual extraction data is collected.

In the Arkansas River region, groundwater withdrawals are required to be metered with totalizing flow meters, pursuant to the outcome of litigation to enforce the Arkansas River Compact. (Amendments to Rules Governing the Measurement of Tributary Ground Water Diversions Located in the Arkansas River Basin, Feb. 28, 1996, rule 3.) If a totalizing flow meter is not used, the well must be rated to determine a power coefficient. The required level of accuracy is ± 5%. If the meter is not operational, water is not allowed be pumped unless a specific backup water measurement program approved by the State Engineer is put into effect. The State Engineer is empowered to grant variances from these requirements in circumstances where strict application of the rules would cause "unusual hardship."

In the Arkansas River region, irrigation diversions of ground water tributary to surface streams are subject to special rules requiring Division approval of a plan for replacement of usable flow at the state line with Kansas. (Amended Rules and Regulations Governing the Diversion and Use of Tributary Ground Water in the Arkansas River Basin, Colorado, Sept. 27, 1995, Rule 3.) As part of these rules, well users are required to furnish monthly records to the division engineer of the amounts diverted pursuant to the plan. If the well is powered by electricity, the user must authorize the power supplier to provide monthly power records to the division engineer. (Id., at Rule 12.) The state and division engineer must regularly tabulate diversions of ground water from the aquifers and make the tabulations available to the public; the tabulations must be summarized annually.

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

The Division of Water Resources receives the data. In some parts of the state, on some water sources, use data is recorded in 15 minute intervals and compiled hourly. Thus, it nearly approximates real-time reporting. The data is compiled by the Division and published in annual reports.

In the Arkansas River region groundwater data is compiled on an annual basis, running from November 1 to October 31. Reports must be filed with the Division Engineer no later than January 31 of the following year.

The Division is presently developing a complex computer-based decision support system (i.e., the "Colorado Decision Support System" or "CDSS") to manage and make use of the data.

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

Principal purposes of measurement pointed to by state officials include monitoring water use to ensure that it is in accordance with water rights. State officials also pointed to:

- limiting waste of water;
- improving water management;
- providing water right owner with an official record that can be certified to the courts, providing a basis for proving historic use in a change of water right case or sale of water right; and
- helping Colorado to meet interstate compact requirements.

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

In regard to surface water, a senior Division official reports that practice lives up to the intended policy objectives. This, he says, is a function of the fact that the Division has adequate staffing relative to the number of surface diversions that need to be addressed by the measurement regime. In regard to groundwater, however, there are thousands of individual wells that would require much greater staffing levels to adequately address. Thus, the agency is more reluctant to undertake groundwater measurement requirements where none now exist, unless adequate staffing levels are available.

NARRATIVE SUMMARY: IDAHO

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

Pursuant to state statute, "appropriators or users of any public waters of the state of Idaho shall maintain to the satisfaction of the director of the department of water resources suitable headgates and controlling works at the point where the

water is diverted.... Each such appropriator shall construct and maintain, *when required by the director of the department of water resources*, a rating flume or other measuring device at such point as is most practical in such canal, ditch, wellhead or pipeline for the purpose of assisting the watermaster or department in determining the amount of water that may be diverted into said canal, ditch, wellhead or pipeline from the stream, well or other source of public water." (Idaho Statutes, § 42-701(1)(emphasis added); see also § 42-703 (regarding measurement devices along/in streams).)

In 1994, in the wake of various conflicts between water users in southern and eastern Idaho during the drought that began in 1987, the legislature amended state law to require the measurement of groundwater diversions and reporting of volumes withdrawn to the Idaho Department of Water Resources.

The state has a complex set of districts involved in water management. The measurement requirements in the state are generally carried out through the district system.

State law requires the Department to create "water districts" for areas in which a court has adjudicated water rights. Measurement requirements are typically part of the court's decree. For each water district there is a "watermaster" who is nominally a state employee, but who is elected and compensated directly by district water users. Thus, watermasters are relatively autonomous compared with some other states such as Oregon. There are more than 100 water districts in Idaho.

State law also authorizes the Department to create "water measurement districts" to accomplish measurement and reporting outside of established water districts. There are three such districts in the state, in which most ground and surface water diversions must be measured and reported and members of the district are assessed for the costs of this work. These are located in the Eastern Snake River Plain Aquifer.

State law also enables ground water users to petition to organize "ground water districts" the creation of which removes an area from a measurement district. A ground water district can do all that a measurement district can do, plus it can develop and operate mitigation and recharge plans as well as represent their members in various legal matters. There are six such districts in the state. Such districts cannot be formed until they have submitted and the Department has approved a plan to implement water measurement over three years.

There is a wide range of measurement practices across the various districts in the state. The Department is in the process of developing statewide measurement guidelines in order to enhance uniformity across the various types of districts.

WHO MEASURES WATER USE?

Within measurement districts, a "district hydrographer" carries out the measurement function. "At the meeting of the appropriators or water users of a district there shall be elected a qualified district hydrographer for such water measurement district, who may be authorized to employ such other qualified regular assistants as the appropriators or water users shall deem necessary, and who, upon qualification and appointment by the director of the department of water resources, shall be responsible for measurement of water as... required within the water measurement district, and the appropriators or water users shall, prior to the election of such district hydrographer and approval of the employment of assistants, fix the compensation to be paid them during the time actually engaged in the performance of their duties." (Idaho Statutes, § 42-707(3).)

WHERE AND HOW IS WATER USE MEASURED?

Points of diversion that are subject to measurement and reporting requirements must have a Departmental "site identification tag" and be located by latitude, longitude, and elevation.

For surface water, the Department's draft Guidelines have identified nine "standard" open channel measuring devices including:

- Suppressed rectangular weir
- trapezoidal flume
- contracted rectangular weir
- Parshall flume
- Cippoletti weir
- submerged orifice
- 90 degree V-notch weir
- constant head orifice
- ramp broad crested weir

The draft Guidelines also provide that the Department may authorize use of non-standard devices or rated sections provided the device or sections are rated or calibrated against a set of flow measurements using an acceptable open channel current meter or a standard portable measuring device.

For groundwater, there are two approaches described: (1) totalizing flowmeters or (2) electrical power consumption coefficient calculations ("PCC"). Devices are required unless they would be "burdensome" for the water user, in which case the user must execute an agreement with the Department regarding use of the PCC approach. The PCC unit is the number of kilowatt hours required to pump one acre-foot of water.

A USGS study showed generally that PCC may be an acceptable surrogate for flowmeter measurements. However, there are some caveats to that generalization. First, where water levels fluctuate, PCC may not be a good surrogate. Second, where the pumping system is complex, PCC may not be a good surrogate. That is, it works well where a single

electrical power meter is dedicated to one pumping plant. Where the system has a variety of valves, discharge locations, or distinct flows and pressures, the agency feels it should be more inclined to require flow meters. Notwithstanding this feeling, the agency has backed off the requirement of flowmeters in some cases because of a sense that users purchase lower quality meters, do not calibrate them well, and do not maintain them properly over time. (Winter weather is also somewhat hard on the meters.)

A time clock method is also sometimes used on constant flow systems.

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

Upon written notice from the Department, users required to measure and report must annually report, among other things, the maximum rate at which diversions have been made during the reporting period, the total volume diverted during the reporting period, and a description of the physical changes to the diversion works that have been made during the reporting period. (Idaho Statutes, § 42-701(1).)

In water districts, "All watermasters shall make an annual report to the department of water resources prior to the expiration of the watermaster's appointment for the current year. This report shall show the total amount of water delivered by the watermaster during the preceding year, the amount delivered to each water user, the total expense of delivery and the apportionment of expenses among users and all debits and credits to be carried over to the following year. Such report shall also include records of stream flow the watermaster used or made in the process of distributing water supplies." (Idaho Statutes, § 42-606.)

In water measurement districts, "All district hydrographers shall make and certify annually a report to the department of water resources, in a form and containing the information required by the director of the department of water resources, prior to the expiration of the district hydrographer's appointment for the current year. This report shall show the amount of water diverted at each diversion as measured or determined by the district hydrographer during the preceding period from November 1 through October 31, the total expense of the district and the apportionment of expenses among users and all debits and credits to be carried over to the following year. Such report shall also include records of stream flow, depth to ground water measurements, current names and addresses of appropriators or water users within the district and such other information as the district hydrographer collected or caused to be collected in the course of completing the duties of the district as instructed by the director." (Idaho Statutes, § 42-708.)

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

According to a Department staff member, the principal purpose is to ensure delivery of the correct amounts by the watermaster. The main benefits include protection of the users' rights by reliably documenting various uses. This is helpful in circumstances involving adjudications as well as transfers (where the agency needs to resolve public protests or limit the transfer). The data is also helpful in ensuring and demonstrating compliance with interstate compact requirements. In this sense, the main purpose is regulatory. In addition, the effort contributes to planning and scientific work relating to statewide water resource management. For example, they have combined use data with satellite data to prepare estimates of evapotranspiration.

In one study, state officials learned that 30-40% of groundwater diversions were exceeding rightful levels.

There tends to be a difference of opinion between the groundwater users and surface users. The groundwater users tend not to care about volumes of water withdrawn since they believe that much of their withdrawals are recharged. Thus, they are more concerned about water levels. At the same time, surface users tend to be concerned about rates of diversion/withdrawal because this may indicate a source of interference with downstream water rights. Thus, surface users are more likely to desire flow meters for upstream users.

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

According to one Department staff person, "measurement is not often a precise science or activity." Everyone wants measurement to be, at the same time, as cheap as possible and as accurate as possible, and those things do not go together.

The state has struggled with the questions of what is the purpose of the data being collected, and what will it be used for. As a result, one Department staff person offers the advice that "You've got to define your objectives first." That then drives the "level of accuracy" desired. And that, in turn, dictates the specific technical approach to measurement. For example, he says, if you decide that you only need accuracy of ± 15 %, you don't need meters, whereas a desired accuracy level of ± 3 % may necessitate the use of meters.

Agency staff have concerns about the accuracy of the data they receive through user measurement. Engaging in quality assurance over that data is a separate and substantial step in the measurement process. In Idaho, agency staff have done only a little field-truthing, which is a time consuming and costly process. Also, there is some problem with the timeliness of reporting. Agency staff do not get involved in reading or calibrating meters.

NARRATIVE SUMMARY: KANSAS

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

The legislature has enacted just two concise statutes. In 1957 the legislature enacted a law stating that "The chief engineer shall have full authority to require any water user to install meters, gages, or other measuring devices, which devices he or she or his or her agents may read at any time, and to require any water user to report the reading of such meters, gages, or other measuring devices at reasonable intervals. He or she shall have full authority to make, and to require any water user to make, periodic water waste and water quality checks and to require the user making such checks to report the findings thereof." (Kansas Statutes Annotated, § 82a-706c.) In pursuit of this mandate, use information was initially collected based on estimates of flow rates and estimates of hours pumped. It was determined that those estimates were not accurate enough in certain situations.

Beginning in the 1980's the Chief Engineer and certain Groundwater Management Districts began requiring water flowmeters in some cases.

In 1988 (amended in 1991) the legislature enacted legislation stating that "The owner of a water right or permit to appropriate water for beneficial use, except for domestic use, shall file an annual water use report on a form prescribed by the chief engineer of the division of water resources of the state board of agriculture on or before March 1 following the end of the previous calendar year. The report shall completely and accurately set forth such water use information as requested by the chief engineer." (Kansas Statutes Annotated, § 82a-732.)

The Kansas Department of Agriculture, Division of Water Resources, has enacted regulations implementing the reporting requirement. Since 1988, the Division has required metering of water use together with reporting.

WHO MEASURES WATER USE?

Pursuant to statute, all permitted water users, including irrigation, are required as a condition of their permits to maintain accurate records from which the quantity of water diverted each calendar year may readily be determined.

The Kansas Department of Agriculture has required approximately 600 water flowmeters per year. The Chief Engineer has so far required about 10,700 meters. There are about 30,000 permits in the state.

All "nondomestic, nontemporary wells and pump sites operated under the authority of an approval of application issued on or after the effective date of [the] regulation shall be equipped with a water flowmeter that meets or exceeds the" agency's requirements. (Regulations of the Dept. of Agriculture, Division of Water Resources, § 5-1-7(a).)

All "nondomestic, nontemporary gravity diversions of water, including irrigation ditches, operating under the authority of an approval of application issued on or after the effective date of this regulation shall be equipped with a continuous recording gauge, or other suitable water-measuring device located at or near the headgate. Before installation, the water right owner shall submit plans and specifications for the proposed gauge, or other suitable water-measuring device, to the chief engineer and shall receive approval in writing from the chief engineer before installing the gauge or other suitable water-measuring device." (Regulations of the Dept. of Agriculture, Division of Water Resources, § 5-1-7(b).) The gauge or measuring device must be accurate to ± 6%.

Anyone who changes any condition on their water right permit has a further condition added requiring measurement. Any additional administrative action on the permit leads to a metering requirement.

WHERE AND HOW IS WATER USE MEASURED?

In the Southwest part of the state all owners of water rights or holders of permits must have a meter. Elsewhere everyone must have a meter only where the Chief Engineer finds that special conditions exist. The areas in which metering has been imposed are all areas where groundwater is a particular concern. However, the state recognizes the interaction between surface and groundwater. Accordingly, the metering requirement is sometimes imposed partially to protect senior surface rights that rely upon base flow in a stream.

There are no statutes or regulations setting forth criteria that the Chief Engineer must or will use in deciding that an area needs measurement. The Chief Engineer has broad discretion. Typically, though, it is done where there is a need to: (1) protect the water source (e.g., reduce depletion of an aquifer), or (2) protect senior water rights from impairment.

When required, the flowmeter must be certified by the manufacturer to register within ± 2% accuracy. There is a very strong emphasis in the regulations on manufacturer quality assurance, as well as proper installation and maintenance. The manufacturer of the flowmeter is required to have an effective quality assurance program, including wet testing a random sample of its products, and to certify this to the state Chief Engineer. The regulations specify further standards that flowmeters must meet, including for example, requirements for weatherproof registers readable even when the system is not operating, flow straightening vanes (except in limited circumstances), totalizers that will not cycle past zero more than once per year, and other specific requirements. Variances from these requirements are available in specified circum-

stances. (Regulations of the Dept. of Agriculture, Division of Water Resources, § 5-1-4.) The regulations also contain very detailed flowmeter installation requirements.

The chief engineer maintains a list of all makes and models of water flowmeters that have been certified by the water flowmeter manufacturer to meet the specifications of the chief engineer.

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

Water use reports are required annually. There is a cooperative division of labor between the Division of Water Resources (which handles water rights issues) and the Kansas Water Office (which is the state's water planning agency). Initially, the Division enforces the measurement and reporting requirement and enters the data into the computer system. The Water Office then compares the data to existing standards and makes sure the data is consistent with known typical water uses for various beneficial uses.

The Water Office kicks out a list for joint follow up by the Water Office and the Division, including for example instances where users reported unreasonable values given what is known for uses of that type. The agencies follow up together in contacting the user to clarify the numbers, submitting follow up letters and making phone calls to clarify information reported. The report is then fixed and the "clean" data is included in the database used for planning and other purposes. Members of the public can access the final database by request, and will see the clean figures; or, if they want, they can obtain the whole file through freedom of information requests, and see any edits that have been made as a result of the agency's data quality control efforts.

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

The main purpose of the effort is "water management." The agencies want the data to help identify the state's priorities. They want to know: "Where are we short? Where are we misusing? Do we have enough for the future? Do we have plans for making sure resources are available?" Using the water measurement information that is collected, the Water Office periodically reflects actual use in its plans, and the Chief Engineer revises its standards for what is a "reasonable" maximum use of water for particular types of beneficial uses. The Division of Water Resources then incorporates those amounts into all new permits as maximum amounts at time of permit issuance. After perfection and an administrative process to finalize the right, the right is limited to actual use demonstrated. Water rights enforcement is thought of as a subset of water management.

The purposes include effective administration of water rights to prevent impairment, to protect minimum desirable stream flows, to conserve water, or to otherwise carry out the duties of the chief engineer as set forth in statutes. (See, e.g., Regulations of the Dept. of Agriculture, Division of Water Resources, § 5-1-7(f)).

The cost of testing the Department's own 20 flowmeters for accuracy is about $2,000 per year. The average cost for an irrigation water flowmeter on a new well or pumpsite is approximately $1,000, including installation. Proper annual maintenance, including annualized replacement costs is estimated to be $75 per meter for the 10,700 meters that have been required by the chief engineer. Flow straightening vanes and measurement tubes add about $100 per meter to the cost of the flowmeters. Non-agency personnel are not required to test flowmeters, but if they do, they will initially incur approximately $1,000 to $5,000 to obtain proper testing equipment and training. They would also incur $200 to $500 annual cost to have their equipment certified to be accurate.

Initially, the emphasis on manufacturer quality assurance engendered some resistance from the device industry. A small number of manufacturers have sub-standard measuring products and they did not do well under this system. As a result, retailers generally do not offer some of the cheap and low quality meters that are not on the agency's list. This has helped to avoid the problem of people buying the cheapest product and not caring whether it provides accurate measurement.

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

About 33 percent of irrigators do not use water meters and many of them had difficulty providing accurate data on the number of hours pumped, and they generally had even more difficulty in providing current data on pumping rates.

Overall actual practice lives up to the intended policy. According to one staff person, metering is a direct method of measuring water use. If the meter works, and it's accurate, then you're getting good numbers. If it's a reliable meter from a good manufacturer, and it is kept well maintained, from an enforcement perspective it is very "straightforward." As a result it is felt that people can manage their water better.

NARRATIVE SUMMARY: OREGON

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

Pursuant to state statute, the Oregon Water Resources Department is responsible for requiring and providing incentives for measurement. According to Department staff, in

the last legislative session, a statute was enacted that nominally established a fund from which the Department can match monies needed for installation and maintenance of measurement devices. As of early September 2001, the fund had no balance. By law, the Department will be able to receive monies by grant and donation, if any.

The Water Resources Commission, an appointed citizen body that oversees the Department, may require the owner of any ditch or canal to construct and maintain "suitable measuring devices at such points along the ditch as may be necessary to assist the watermaster in determining the amount of water is to be diverted into the ditch from the stream, or taken from it by the various users." (Oregon Revised Statutes, § 540.310 ("ORS").) Headgates *are* required; measuring devices and flumes *may be* required.

It is the norm, not the exception, for there to be a watermaster. There are twenty watermasters statewide for the twenty Department districts.

Since 1993, in responding to applications for new water rights, the Department has routinely included permit conditions concerning measurement and reporting. These conditions either require measurement and reporting or allow the Department to require it under the terms of the permit if necessary in the future. For small diversions, the permits say that neither measurement nor reporting is presently required but either or both may be someday. For medium diversions, the permits say that measurement is required now and reporting may be required someday. For large diversions, the permits say that both measurement and reporting are required now.

When a permit condition provides for the possibility of future measurement, the Department invokes that provision by posting a "headgate notice." The Department posts approximately 5 or 6 headgate notices per year requiring measurement devices. If the owner of an irrigation works refuses or neglects to put in required headgates, flumes or measuring devices, the local Watermaster from the Department can close the ditch. (ORS, § 540.320.)

Owners and managers of reservoirs on natural streams must install measuring devices above and below the reservoir. (ORS, § 540.330.) If the owner or manager of the reservoir fails to comply, the Watermaster can open the outlet to the reservoir. (ORS, § 540.330.)

The Commission may adopt a rule to designate an area as having "serious water management problems" and order affected water right holders to submit annual water use reports in that area. (Oregon Administrative Rules, § 690-085-0020 (1).) A variety of circumstances can give rise to such a designation including, for example, frequent water management disputes that cannot be privately resolved, substantial interference between wells, frequent water shortages, and other circumstances. (Oregon Administrative Rules, § 690-085-0020 (1).) Petitions proposing designation of an area should include a proposed program describing "any measuring devices to be required, information which would be submitted on any annual water use reports and proposed procedures for regulation of water use." (Oregon Administrative Rules, § 690-085-0020 (3).) The adopted rule must specify "the nature of the problem, the boundaries of the area involved, who is required to install measuring devices, specifications for the types of measuring devices and annual reports, and timelines for implementation." (Oregon Administrative Rules, § 690-085-0020 (6).) The provisions regarding serious water management problem areas are on the books, but have never been used.

Under the "Oregon Plan for Salmon and Watersheds" numerous agencies have committed to measures for improved management of the state's aquatic resources, including steps that can help increase instream flows. The Water Resources Department has committed to a measure called "WRD 20—Water Use Measurement and Reporting," which has been assigned a "high priority" status. Summarized, WRD 20 calls for: (1) expediting entry of water use data into the Department's database and flagging of reports for quality assurance purposes; (2) inventorying significant diversions to ensure adequate headgates and measuring devices and helping users with improvements; (3) helping public entities improve measurement programs and data quality; (4) providing the Commission with any needed recommendations regarding proposed designations of "serious water management problem areas"; and (5) monitoring effects of such designations on water use and streamflows, and if such designations show effectiveness at increasing streamflows considering further designations. Staff are carrying this effort out incrementally over time, focusing initially on compliance with measurement requirements at "significant diversions" (e.g., greater than 5 cubic feet per second).

WHO MEASURES WATER USE?

Under existing law, governmental entities must measure water use. Private entities may be required to do so, either individually or as part of a group within a designated geographic area where measurement is required.

Water use measurement has been required for public users since 1987. (ORS, § 537.099.) "Any governmental entity that holds a water right" (i.e., cities, counties, irrigation districts, federal agencies and others) has been required to measure to 15% accuracy and report to the Department once each year.

Also, the Department has been imposing on selected individuals permit conditions to require measurement. The

Department has broad authority to impose such conditions under a statutory provision stating that water rights permits "shall set forth any terms, limitations and conditions as the department considers appropriate." (ORS, § 537.211.) The individuals chosen to be subject to measurement requirements are chosen on the basis of size of diversion or existence of special circumstances warranting measurement.

WHERE AND HOW IS WATER USE MEASURED?

The Department's regulations set forth numerous approaches that meet the required degree of accuracy. The regulations further provide that all methods must be approved in advance by the Department, except those already approved in the regulation. Alternative methods can be used if a registered professional engineer certifies to the Department that the method will report use to the required degree of accuracy. (Oregon Administrative Rules, § 690-085-0015.)

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

Approximately 800 entities presently report to the Department. By the end of each year, any governmental entity holding a water right must submit to the Department a report of monthly volume of water use for each major use at each point of diversion over the past year (i.e., October 1 to September 30). (Oregon Administrative Rules, § 690-085-0010 (1).) The accuracy of the reports must be ± 15%. (Oregon Administrative Rules, § 690-85-0010 (3).)

Under limited circumstances, the user/governmental entity is allowed to assume that the monthly use is the maximum allowed under the right and permit, and may report that volume. Such circumstances include where the Department has approved a time extension for compliance due to economic hardship. (Oregon Administrative Rules, § 690-85-0010 (4).)

The Commission may waive compliance with the accuracy standard and the prescriptive measurement methods set forth in the administrative rules, in a case where there would be an economic hardship and where the information collected "would not materially aid water management." (Oregon Administrative Rules, § 690-85-0010 (6).)

Over the past ten years the Department has put in place a data management system, which incorporates rights data, gauging data, and reports of water use. An agency official reports that the data is posted to the agency website, but the agency has been slow to get it posted. This is due to staffing shortages combined with a desire by the agency to post the data only after it has gone through a quality assurance check. The agency has used the data in developing its statewide water availability model. The USGS has also used it in developing their 5-year water use reports.

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

Staff indicate that they have drawn a sharp distinction between two broad purposes: (1) prevention of "waste"; and (2) improved efficiency. This distinction is important, they feel, because while efficiency is good, waste is illegal. That is, it is unlawful to use water in a manner that exceeds one's permitted rights. Since waste is illegal, there is little need to discuss it. It is basically assumed by everyone that the agency has an appropriate role in reducing illegal use of water and that measurement can contribute to that. As a result of this distinction, their public discussion and debate has focused on the purpose of improving efficiency and the best ways to do that. Also, they generally believe that bigger savings are available through improved efficiency than through enforcement (e.g., looking for potential locations for canal lining rather than looking for people using sprinkler systems to water pavement).

In articulating a proposed future strategy to the Commission, agency staff identified the following purposes for measuring water use:

- The information can benefit water right holders by increasing awareness of the amount of water they use and providing the basis for self-regulation.
- Measurement data may be used by water right holders to develop improvements in their business operations and to plan for present and future needs.
- Water use data can provide reliable evidence for water right holders to rebut allegations of forfeiture for non-use.
- Water measurement information assists the watermaster in the effective distribution of water in accordance with the rights of record.
- Water measurement provides scientific data that can help Oregon Plan recovery efforts by providing accurate information to help with streamflow restoration projects or improve water distribution efforts.
- Water measurement data is important to help staff update and refine the water availability model, and develop other needed technical analyses that are the basis of fair and sensible management decisions.

In articulating the purposes in a more specific fashion, related to particular agency programs, staff identified the following purposes:

- Water measurement data is used to refine and update our water availability model, which is used to evaluate whether new water right permits may be issued.

- Water use measurement data provides information for use as final proof evidence for water right certification.
- Historical water use data is used to support injury determination for proposed water right transfers, permit amendments, exchanges and voluntary instream leases.
- Water use information is important to support projects to improve water use efficiency and projects to conserve water under the Allocation of Conserved Water program [under which users may get to keep some water that they conserve].
- Water measurement information supports Department actions to distribute and regulate water use for the protection of senior water rights.
- Water measurement data is used to help staff monitor instream water rights and flows, and to monitor the effects of streamflow restoration projects.
- Water measurement information can act as an early warning system for catastrophic flood events.
- Measurement data is used to coordinate water release schedules for stored water.
- Water use measurement information is important to monitor the status of critical ground water areas.
- Measurement and reporting data is central to the purposes of the Annual Water Use reporting program, which affects public water users.
- Generally, lack of accurate measurement data in these program areas does not prohibit staff from carrying out their responsibilities. However, as issues related to water use become more complicated, and the competition over remaining available water resources intensifies, water use-related actions will be subject to increasing scrutiny and challenges. Water measurement information provides a firm foundation for staff to make good decisions in implementing Department programs.

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

The policy and legal requirements presume that people will willingly participate, willingly maintain measurement devices, understand what is required, and willingly meet the accuracy standard. An agency official reports that "some people will comply when it is in their interests, but most users will not and would just as soon not share their information with anyone." Where the agency has required measurement by permit condition they have less than a 50% compliance rate.

An agency official reports that "a voluntary program, without quality assurance monitoring, does not work. A good measurement and reporting program takes a lot of resources."

An agency official further reports that staffing levels are insufficient to assure compliance with the measurement requirement and the requirements regarding the degree of accuracy needed in measurement devices. They regard their own staffing levels for field staff as being substantial, but still insufficient (approximately 55 to 60 people). It is an enormous undertaking, one official reports, and a particular challenge to ensure data quality.

Their experience does confirm that people use less water when it is measured. Staff has looked at a couple of areas of the state and know that water use went down. The agency has never formally written up these findings, though.

An agency staff person reports that there is a common misperception that there is a "magic way to measure" whereby one can easily just install a standard piece of technology once and the data somehow "just comes back to your computer." There is often an insufficient appreciation of the fact that measurement of agricultural water use involves a labor intensive and ongoing effort involving construction of weirs, gauging stations, flumes, meters, and controls, and that there is a professional exercise of technical judgment needed in constructing and rating these.

NARRATIVE SUMMARY: WASHINGTON

WHO REQUIRES OR PROVIDES INCENTIVES FOR WATER USE MEASUREMENT?

The state Legislature has adopted a statute that requires measurement of water use in specified circumstances. (Revised Code of Washington, § 90.03.360.) The state Department of Ecology is charged with implementing the statute. The Department is currently in the process of issuing new regulations to implement the statute.

WHO MEASURES WATER USE?

State law enacted in 1993 requires measurement of water use by any "owner" of "any water diversion." State law requires the Department of Ecology to enforce the requirement for measurement in more limited circumstances. Specifically the requirement must be enforced in regard to:

- all holders of new surface water rights permits;
- all holders of existing surface water rights permits greater than one cubic foot per second;
- all holders of existing surface water rights permits diverting from sources that support salmonid fish stocks classified as "critical and depressed" by the Washington Department of Fish and Wildlife; and
- all holders of existing groundwater rights withdrawing from sources that support salmonid fish stocks clas-

sified as "critical and depressed" by the Washington Department of Fish and Wildlife.

In regard to groundwater, the Department of Ecology may require persons obtaining new water rights permits to meter their withdrawals, or to measure them by other approved means. (Revised Code of Washington, § 90.44.450.) State law exempts certain small groundwater withdrawals from the requirement of obtaining a permit, but allows the Department of Ecology to require that anyone making such exempt withdrawals "furnish information as to the… quantity of that withdrawal." (Revised Code of Washington, § 90.44.050.) Department officials report that they have "no intention" of requiring measurement of exempt wells. The Department is also authorized to investigate the state's groundwater resources, and, in so doing, may "require reports" from each groundwater appropriator as to the amount of their withdrawals. (Revised Code of Washington, § 99.44.250.)

Metering and measurement of new groundwater permits is not required, except where: (1) such permits are granted in areas where salmon stocks are depressed or critical, as determined by the state Department of Fish and Wildlife, and (2) the Department of Ecology has a basis for believing that the groundwater right may affect surface waters supporting depressed or critical stocks. (American Rivers, et al. v. Washington State Dept. of Ecology, Thurston County Superior Court, civil case no. 99-2-00480-6, Order Filed March 22, 2000, para. 3.)

WHERE AND HOW IS WATER USE MEASURED?

Water use is to be measured at the point of diversion by means of "metering or other approved methods." This measurement requirement is implemented by means of a condition that the Department of Ecology imposes on water rights permits.

In 1993 the state Legislature enacted the legislation requiring measurement by diverters and enforcement by the Department of Ecology. In 1994, the state legislature cut the Department's budget and the Department lost approximately 70% of its staff. In 2000, a Washington state court held that the Department of Ecology had not been complying with the statute. (*American Rivers, et al. v. Washington State Dept. of Ecology*, Thurston County Superior Court, civil case no. 99-2-00480-6.) To conform with the court's order, the Department has drafted new regulations. (To be codified at Washington Administrative Code ("WAC"), chapter 173-173.) Those regulations would require measurement and establish "standards of acceptability for measuring devices and methods." Under the proposed regulations, no withdrawal or diversion of water is allowed to be made unless the required measuring devices and facilities are in proper operating condition, or are being repaired and the diverter provides "a reasonable estimate" of use during that time. (Proposed WAC, § 173-173-090, subds. (1)-(3).)

The proposed regulations include standards for accuracy of measurement devices and methods, but do not require specific technologies or systems. That is, they use a performance standard approach.

For *pressure systems*, meters must be totalizing, and the default required level of accuracy for meters is ± 5% and for the "measuring system" as a whole ± 10%, but those levels can be changed by the Department of Ecology on its own or upon request of a water user. (Proposed WAC, § 173-173-100, subds. (1)-(4).) For other conditions needed to ensure accurate and precise measurement, the regulations also point to "generally accepted industry standards," including those of the American Water Works Association and information provided by measuring device manufacturers. (Proposed WAC, § 173-173-090, subd. (6).)

For measurement on *open channels*, the default required level of accuracy for the "measuring system" as a whole is ± 10%. (Proposed WAC, § 173-173-130, subd. (1).) For other conditions needed to ensure accurate and precise measurement, the regulations also point to "generally accepted industry standards," including those of the U.S. Bureau of Reclamation's *Water Measurement Manual, 3rd edition*, and information from the manufacturer or designer.

Indirect and alternative methods are also contemplated. In specified circumstances, power consumption data may be substituted for more direct flow measurement methods. (Proposed WAC, § 173-173-160.) Alternative measurement devices and methods are allowed if approved by the Department of Ecology in writing and a registered professional engineer certifies that the approach will achieve the required accuracy. (Proposed WAC, § 173-173-170.)

WHO REPORTS, COMPILES, STORES, DISTRIBUTES, AND USES MEASUREMENT INFORMATION AND HOW?

Persons required to measure and report water use will be required to report the "maximum instantaneous discharge (flow rate) of water diverted or withdrawn over the reporting period." (Proposed WAC, § 173-173-060, subd. (1).) Average diversions of greater than 200 gallons per minute will be recorded daily; average diversions of 10-200 gallons must be recorded weekly; and average diversions of less than 10 gallons per minute must be recorded monthly. (Proposed WAC, § 173-173-060, subd. (2).) Regardless of the size of the average diversion or length of the recording period, all reporters must include annual total volume and file the reports annually in January and February. (Proposed WAC, § 173-173-060, subd. (2).)

The Department of Ecology anticipates a "flood" of data from implementation of the statute and new regulation. No

system is in place yet for management of the data. The Department has hired a programmer who is looking at this issue. By the end of 2002, the Department hopes to have a data management system in place, including an internet-based capability for completing and submitting required forms.

Statewide, the Department presently has approximately 6 Full Time Equivalent ("FTE") staff assigned to measurement work and another 4 FTE assigned to compliance work generally, some of which includes compliance with measurement requirements.

WHAT ARE THE PURPOSE(S), BENEFITS, AND PROBLEMS OF THIS APPROACH?

As indicated by the emphasis on "critical and depressed" salmonid streams, one prominent purpose of the measurement regime is:

- maintenance of adequate instream flows for protection of salmonid habitat.

Other purposes referenced in the regulations and supporting documents include:

- verifying water rights compliance;
- providing a basis for curtailing diversions in excess of authorized water rights in order to make more water available for aquatic habitat;
- determining the availability of water for further appropriation;
- identifying opportunities for more efficient water use;
- conducting any needed hydrologic studies; and
- maintaining flexibility in the approach in order to implement any recommendations of watershed planning groups.

One potential unintended consequence identified as a concern by the Department of Ecology "is that water users may feel compelled to maximize their water use such that the quantity equals the amount originally specified by a water right permit, certificate or claim. This is because a user may fear that he or she will relinquish the right to divert water that is not actually put to beneficial use. The measurement of water use and the reporting of water use data to the state may heighten this concern. However, an important element of beneficial use is that the water use must be reasonable and not wasteful. Diverting or withdrawing a certain quantity of water does not give the appropriator a legal right to that quantity if it exceeds what is reasonable for a specified use." (Environmental Checklist for proposed WAC, § 173-173-060.)

DOES ACTUAL PRACTICE LIVE UP TO INTENDED POLICY INCENTIVES OR LEGAL REQUIREMENTS?

No. The Department of Ecology recently lost a lawsuit in which environmental advocacy groups argued that the Department had failed to properly implement and enforce the law.

WHAT DOCUMENTS ALREADY EXIST ON THIS ISSUE (E.G., COST/BENEFIT ANALYSES)?

The Department of Ecology has prepared a form of cost-benefit analysis in connection with its current proposed regulation. This analysis is contained in a so-called "Small Business Economic Impact Statement." (Washington State Register, 01-16-131, filed July 11, 2001.) As required under Washington state law, the analysis only focuses on private sector entities. The analysis found that the economic impacts of the regulation fell disproportionately on smaller businesses, but that the impacts were not large relative to revenues for small or large businesses (i.e., ranging from $0.0001 per $100 of revenue to $0.11 per $100 of revenue. The analysis points to the following features of the proposal as tending to mitigate impacts on smaller enterprises: (1) use of performance standards; (2) reduced frequency of required recording and delayed reporting for smaller diverters; (3) provision for measurement by indirect and alternative means; (4) provision for alternative reporting formats; (5) the state legislature appropriated $3.4 million in 2002-2003 for measuring devices and stream gauges (although it is not clear whether these monies can be used for measurement of diversions).

Under the state Administrative Procedures Act, the Department must also determine before adoption that the benefits of adopting the rule will exceed the costs of the rule, considering both quantitative and qualitative factors.

APPENDIX D:
SUMMARY OF STAKEHOLDER COMMENTS

BACKGROUND

The materials included in this final Panel Report were developed with the ongoing involvement of and comment by diverse stakeholder groups.

The Panel process, begun in June 2001, included the participation of stakeholders with both policy and technical expertise. All Panel meetings were conducted in public. The Technical Team met informally with representatives of affected stakeholder communities throughout the process to seek their focused input. And, finally, a series of public workshops were held over the past two years to keep interested members of the public informed.

In the most recent round of workshops—held May 2003 in Willows and Fresno—and in written comments received following the Panel's final set of deliberations June 9, stakeholders offered a number of comments on the technical analysis and staff draft findings presented for the Panel's consideration.

Below is a summary of these most recent stakeholder comments. Some comments have been incorporated into this Final Report. Others were considered, but not included. In all cases, the comments were presented to the panelists for their consideration—either at the Panel meeting itself or in follow-on communications.

COMMENT SUMMARY

In general, stakeholders voiced strong support for the technical analysis presented to support the Panel's June 9 deliberations, characterizing it as being both comprehensive and well documented. They also offered targeted critiques and suggested several specific revisions.

The bulk of stakeholder comments focused on technical changes needed to strengthen the analysis and ensure its accuracy. Many of these comments have been incorporated by the Technical Team into the final version of this Report. Other observations, however, focused on more substantive topics. Below is a summary of these primary issues.

LINKAGE BETWEEN ON-FARM MEASUREMENT PRACTICES AND WATER USE EFFICIENCY

The most significant comments focused on farm-gate deliveries, with commentors taking exception to the Technical Team's analysis of the linkage between on-farm measurement practices and water use efficiency objectives. Below is a brief synopsis of these comments.

- At least one commentor indicated that the Panel's focus on state and federal objectives minimizes the important linkage between on-farm measurement and potential efficiency improvements. The Panel considered the comment, but reiterated its view that the analytic structure does encompass the connection between on-farm measurement and objectives related to water use efficiency. Additionally, while the Panel agrees that the Final Report should more clearly articulate the beneficial role on-farm measurement can play in demonstrating the effects of water use efficiency measures, it re-emphasized its collective view that measurement also fosters important objectives related to planning, water availability and transfers.

- Several stakeholders suggested that the technical analysis is incomplete because it does not take into account costs and benefits associated with potential on-the-ground water management changes necessary to yield tangible water flow, timing or quantity benefits. As a result, these stakeholders said, the analysis is likely

to recommend measurement practices that are not, in fact, truly cost-effective. The Panel recognizes the value of incorporating project-specific costs and benefits, but the work to-date suggests it is not now feasible to credibly anticipate and quantify local actions. Moreover, the current analysis suggests that measurement itself—even uncoupled from potential on-the-ground water management changes—is a necessary step to help state and federal water managers better understand an increasingly stressed system and target resources in a manner that will save money in the long run. The Panel recommends that project-specific costs and benefits can and should be quantified when a project is submitted for funding in order to ensure that limited resources are appropriately targeted.

- Given California's increasingly scarce water resources, some stakeholders contended that it is necessary for the State to take steps that ensure the highly efficient use of water at the on-farm level. Accordingly, these stakeholders said, it is important for on-farm deliveries to be measured so that users can be charged volumetrically, thereby receiving the price signals that will result in more efficient water management practices. Some stakeholders further argued that a "high" level* of farm-gate measurement should be mandated to facilitate this form of incentive pricing. A review of the current literature suggests that measurement of farm-gate deliveries can, indeed, have an impact on statewide efficiency objectives; farm-gate measurements, coupled with volumetric pricing, frequently result in lower water applications. However, the literature also shows that current measurement practices in California are largely sufficient to support volumetric pricing. What's missing—and, accordingly, where the Panel's recommendations are focused—are the collection, management and use of data by locals.

PANEL RECOMMENDATIONS ARE TOO PRESCRIPTIVE

Some stakeholders suggested top-down prescriptions are not the most effective strategies for eliciting water-user changes at the local level. Moreover, they noted, such an approach is not consistent with foundational CALFED and Water Use Efficiency Program incentive-based and voluntary implementation principles. For these stakeholders, any analysis that seeks to define "appropriate measurement" from a statewide perspective is inevitably steering towards a command-and-control approach. The Panel believes that its definitions are regionally sensitive and not overly prescriptive. Moreover, the definitions of appropriate measurement are not intended to either lock in or preclude any particular implementation approaches that are to be developed, post-Panel, through Authority-sponsored discussions with a balanced cross-section of affected stakeholder communities.

RECORD OF DECISION COMMITMENTS NOT ACCURATELY INCORPORATED

At least one commentor recommended that the final report more fully incorporate measurement-related language from the August 2000 Record of Decision (ROD). The document has been revised to fold in more complete language from the ROD. Additionally, the commentor suggested that volumetric pricing is included as a ROD objective. The Technical Team acknowledges that the ROD says that measurement will "enable water purveyors to charge for water according to the amount used." Accordingly, the analysis considers the level of measurement "appropriate" to support volumetric pricing. The WUE Program Manager does not, however, believe it is within the purview of the Panel to recommend volumetric pricing as part of its definition.

OTHER COMMENTS

Commentors offered a handful of other substantive comments and observations. These included recommendations that:

- The final version of the Panel Report be revised to adequately distinguish between objective and subjective findings incorporated in the Technical Team's analysis.
- The Authority take steps to ensure that the Panel Report serve as the underpinning for the development of an implementation approach by an Authority-convened stakeholder group and not simply forwarded to the Legislature for its consideration.
- The Technical Team's analysis of measurement practices needed to support volumetric pricing and state groundwater allocation not be included in the definition of appropriate measurement, but rather incorporated into the analytic supporting materials.
- The Authority and affected stakeholder communities recognize that the expected benefits, while valuable, are long-term in nature and unlikely to help agriculture address its most pressing concern: How can it increase the certainty of annual allocations in the immediate future?

The Authority invites interested stakeholders to submit additional comments based on this final Panel Report.

* As discussed elsewhere in this Report, a "high" level of farm-gate deliveries requires measuring flow rates, on average, three times per structure use or at least three times per day during continuous use.

APPENDIX E:
GLOSSARY

Bulletin 118: Ground Water Basins in California prepared by Department of Water Resources: http://www.waterplan.water.ca.gov/groundwater/118index.htm

Bulletin 160: California Water Plan update prepared by Department of Water Resources: http://www.waterplan.water.ca.gov/b160/indexb160.html

CIMIS: California Irrigation Management Information System.

Conductivity (EC): EC represents salt content in water.

Crop coefficients (Kc): A factor used to convert a reference evapotranspiration rate to a particular crop evapotranspiration rate.

Central Valley Project Improvement Act (CVPIA): Also known as Public Law 102-575, passed by the United States Congress in 1992.

Evapotranspiration (ET): Amount of water transpired by the crop, retained in its plant tissue, and evaporated from adjacent soil surfaces during its growing season.

Flow meter: Mechanical or electrical device that measures the rate of flow through a know area.

Flow-path: Describes the route of water through a system.

Geographic Information System (GIS): Software package that is used to display geographically referenced information stored in databases

LANDSAT: A U.S. satellite that collects images of Earth: http://www.landsat.org/about.html

Surface Energy Balance Algorithm for Land (SEBAL): A process to estimate crop evapotranspiration from satellite imagery: http://www.waterwatch.nl/

Telemetry: The transmission of electronic information from one location to another, usually through radio communication.