

Implementing California's Sustainable Groundwater Management Act (SGMA)

Using Research on California's Existing Groundwater Management Experience to Inform SGMA Implementation

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This research effort is guided by the following overarching research question: What can be learned from existing groundwater management arrangements in California — adjudications, special act districts, and select AB 3030 planning processes and county ordinances — to inform the creation of durable, sustainable groundwater management plans under California's new Sustainable Groundwater Management Act? The current and planned research described in this presentation is being conducted with a team of researchers at Stanford University's Woods Institute on the Environment, Water in the West Program, and Gould Center on Dispute Resolution. Preliminary work is being supported by a grant from Stanford's Environmental Ventures Program (Janet Martinez, PI).

About SGMA

Groundwater provides between one-third and two-thirds of freshwater supply annually in California (DWR 2013), depending on weather conditions and water use patterns. The percentage rises in dry years the percentage rises, as groundwater is used to replace diminished supplies from surface water sources. To some extent, this variation in groundwater use occurs anywhere—surface water bodies such as streams and lakes respond more quickly to dry weather, and users who have the option of tapping groundwater supplies can be expected to do so when surface sources are low.

There is also an institutional dimension to California's greater dependence on groundwater: surface water supplies are regulated and controlled to a much greater degree than groundwater, so users facing drought-triggered restrictions on surface water deliveries turn to groundwater to compensate. California water law not only fails to restrain groundwater use; it provides protection to the rights of groundwater users and may even be said to encourage groundwater withdrawals.

The recent drought combined with the institutional setting governing California water use to produce a spike in groundwater extraction and historic declines in groundwater levels and the amount of groundwater in storage. The severity of the drought has been unprecedented in modern times. In Spring 2015, measurements of the Sierra Nevada snowpack – which feeds the major surface water projects in the state – recorded just 6 percent of average annual values. The previous low mark had been 25 percent, which had

occurred only since the state government began the snowpack measurements. Water use restrictions went into effect throughout the state, and the major surface water projects delivered little or no water to their recipients.

Concern escalated throughout the drought about the accelerating declines in groundwater levels and groundwater in storage. In fall 2014, at the end of the third year of what is now a five-year drought, the California legislature passed and Governor Jerry Brown signed the Sustainable Groundwater Management Act (SGMA).

Despite the general concern among California state policymakers and the general public, SGMA does not create a state system of groundwater management or a state groundwater management agency. California is a large state that is diverse in almost every imaginable way, including the presence, characteristics, and use of groundwater resources. For instance, reliance upon groundwater use across hydrologic regions within the state varies between 9 and 86 percent of total water supply. Rather, SGMA mandates that local governments develop and implement groundwater management plans, with some important exceptions to be discussed later.

What SGMA Does. The law requires a) that groundwater sustainability agencies (GSAs) be identified or created by June 30, 2017 for all medium- and high-priority groundwater basins in the state, b) that groundwater sustainability plans (GSPs) be completed by either January 31, 2020 or January 31, 2022, depending on the groundwater basin, and c) that implementation of those GSPs result in attainment of sustainable management within 20 years. Fundamentally, SGMA requires local agencies to form GSAs that will be responsible for the development and implementation of GSPs. The development of GSPs will require agencies to determine a basin's "sustainable yield" and then manage toward its achievement (Moran and Wendell 2015).

"Sustainable yield" is defined in SGMA as the "maximum quantity of water ... that can be withdrawn annually from a groundwater supply without causing an undesirable result." The undesirable results to be avoided are defined to be any one or more of:

1. Chronic lowering of groundwater levels resulting in a significant and unreasonable depletion of supply;
2. Significant and unreasonable reduction of groundwater storage;
3. Significant and unreasonable seawater intrusion;
4. Significant and unreasonable degraded water quality;
5. Significant and unreasonable land subsidence;
6. Depletion of interconnected surface waters that have significant and unreasonable adverse impacts.

The Act thus mandates that local GSAs develop and implement GSPs that will end or prevent these "undesirable results" of chronic groundwater overdrafting. These definitions of sustainable yield and undesirable results allow for a range of management options.

The establishment of GSAs for groundwater basins is the first procedural step in implementing SGMA. The procedure seems relatively straightforward. A local agency that

wishes to become the GSA for a particular groundwater basin must first publish a notice pursuant to Section 6066 of the Government Code. After publishing the notice, the local agency (or agencies—see below) must hold a public hearing in the county or counties overlying the basin. The governing board(s) of the agency/agencies must vote to request GSA designation. Then within 30 days, the GSA must inform the California Department of Water Resources of its to undertake groundwater management responsibilities in that basin, and the department will post notice of the petition. If no other notice of request for GSA designation in that basin is posted within 90 days, the petitioning GSA is presumed to be the exclusive GSA within the basin it accepted responsibility for managing.

Although the GSA designation procedure appears straightforward, the formation of GSAs will present some challenges. There are 127 groundwater basins in the state that covered by SGMA at this point. There are approximately 2,300 local agencies across California currently involved in some aspect of groundwater management (Nelson 2012). Failure to obtain GSA designation in any of the 127 basins may trigger state intervention, although SGMA states that county governments are presumed to be the GSAs for unmanaged areas in the basins within their boundaries, placing counties in the position of being the local “backstop” before state intervention would occur.

Under SGMA, local public agencies with water management, water supply or land use responsibilities are eligible to become GSAs. GSAs may be public water agencies/districts, counties, or municipalities. Local agencies may come together to create a single GSA (e.g., through the establishment of a joint-powers agency or similar structure) to manage the basin in a coordinated manner. Furthermore, SGMA allows a single or multiple GSAs to manage a groundwater basin, either through a single GSP or separate but coordinated GSPs in the same basin.

Whether or not they become GSAs, local water and land use agencies retain their existing authorities and responsibilities. County and municipal agencies are specifically granted primacy over land use and well permitting, construction and abandonment responsibilities. The challenge for water and land use agencies will be to bring their existing authorities, expertise and resources to the table to meet the expectations of SGMA. Also, regardless of how and which GSAs are formed in a basin, land use agencies are required to take into consideration the information in the GSP during a revision or update to their general land use plans. This is clearly intended to advance the integration of land use and water resource management, although it is likely to entail coordination costs and raise problems if coordination is perceived to be lacking.

GSAs also need to incorporate representation of certain interests into their decision making structures or through participation processes. The interests so designated by SGMA include “all beneficial uses and users of groundwater” -- i.e., overlying property owners, public water systems and other appropriators, and environmental users -- plus surface water users, the federal government, Native American tribes in California, disadvantaged communities, and listed monitoring entities.

One might wonder at this point why any local agency or agencies would want to become GSAs. The answer lies partly in the authority that GSAs will acquire under SGMA—powers that are currently missing from most local agencies' authority. GSAs gain powers to manage local groundwater to achieve sustainability goals, including well registration, wellhead metering, monitoring, reporting, allocating groundwater production, assessing fees, taking enforcement actions, and, where feasible and needed, groundwater recharge, conjunctive management, changes in land use, pumping reductions, or some combination of the above.

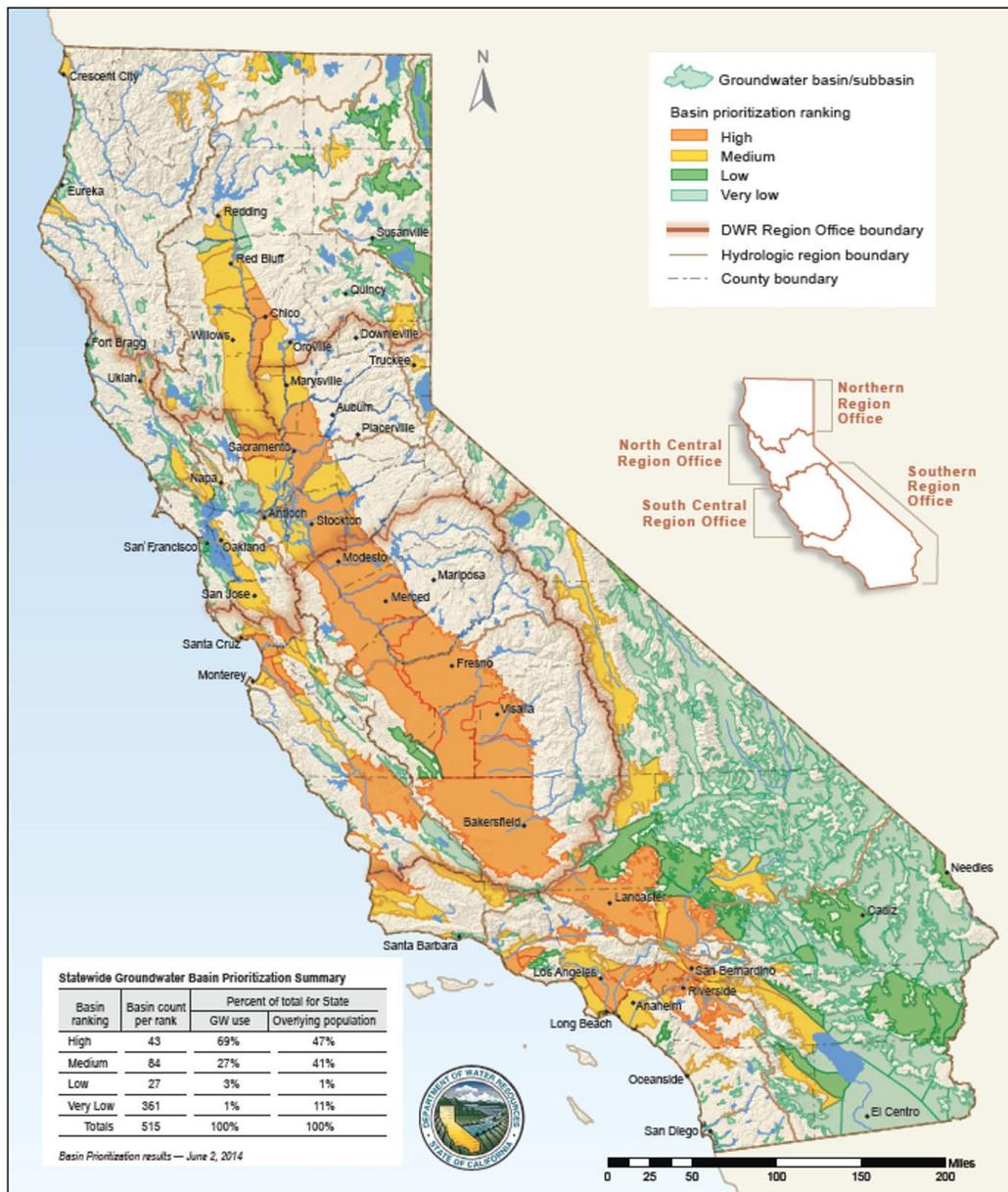
The other principal motivation for forming GSAs lies in the preference for local control over state interventions. In the 127 basins, local agencies and groundwater users face the threat of state preemption if they are unable to form a GSA by the June 30, 2017 deadline, or if they fail to develop GSPs that satisfy SGMA requirements by the January 31, 2020 and January 31, 2022 deadlines. It is anticipated that in most basins, local agencies and groundwater users will prefer to develop local solutions rather than accept state intervention. Whatever the relative weight of these two motivations, or the presence of some other motivation not considered above, local agencies do appear to be expressing interest in becoming GSAs and the Department of Water Resources has been receiving and posting petitions.

The Department of Water Resources is still developing further guidance and more detailed requirements concerning the GSPs that GSAs will have to produce. Given the deadlines in SGMA, the procedure for getting GSAs formed had to be put in place first and occupied most of the department's attention from the time of SGMA passage through calendar year 2015, and the development of instructions for GSPs is expected to be the department's focus for the remainder of this year.

What SGMA Excludes. The legislation applies only to groundwater basins that the Department of Water Resources has identified as being either high- or medium-priority. The department identifies 515 basins in the state, of which 43 are classified as high-priority, and 84 as medium-priority. These are the 127 groundwater basins covered by SGMA. The map below shows the department's priority classification of groundwater basins in the state following SGMA's enactment.

Although 127 basins out of 515 may seem to be a small percentage, those 127 basins account for approximately 88% of the population and 96% of groundwater use in California (DWR 2014). Remaining basins are classified as low or very low priority. Although the state encourages these basins to develop GSPs, their development is not required under SGMA. Of course, the possibility remains that unconstrained groundwater pumping or other changes in groundwater conditions in these low and very low priority basins in the future could lead to adverse impacts and possible changes in priority in the future, but this is not specifically addressed in SGMA.

CASGEM Groundwater Basin Prioritization



Additionally, SGMA exempts 29 basins where local groundwater management already exists. Despite the general and often-repeated observation that groundwater in California is unmanaged, in fact some groundwater basins in the state are nationally and even internationally known for effective management of groundwater and for innovation in groundwater replenishment, water conservation, water reuse, and the conjunctive management of surface water and groundwater resources.

Perhaps most important, SGMA does not make any changes to California’s complex array of legally recognized groundwater rights. SGMA implementation will require local agencies, groundwater users, and other stakeholders in many parts of the state to make difficult

decisions and take potentially contentious actions in order to meet the act's requirements and goals. The difficulties attending those decisions are likely to be exacerbated and vulnerable to litigation if actions such as groundwater pumping reductions are viewed as interfering with property rights.

Relationship to Ostrom Workshop Research

SGMA places management authority at the local level, which means that the individuals and organizations engaged in planning and management activities in each basin will have to resolve a host of governance and technical issues, including how to best use information and make extremely contentious decisions. Research is needed and under way to develop a broad knowledge base from current groundwater management arrangements that operate within California's legal and political environment, i.e., those basins that are exempt from SGMA because they are already being managed.

SGMA's requirements are ambitious and its deadlines are coming quickly, so there is a critical need in basins throughout the state for sound information and advice on how to: establish workable basin-scale decision making arrangements, exercise groundwater management powers under conditions of rivalrous consumption of an overused common-pool resource, develop and implement management plans that will bring overdrafted basins back into conditions of supply-demand balance, and sustain and adapt these arrangements over time. Results from this research will be used to aid local decision makers in developing and implementing management arrangements that address their highest priorities while satisfying the requirements of SGMA.

The Ostrom Workshop has been the site of the most significant and most utilized research on groundwater management institutions in California. It was the subject of Lin Ostrom's Ph.D. dissertation at UCLA (E. Ostrom 1965), and became one of the key examples on which she relied in developing the analysis and design principles for long-enduring common-pool resource management institutions in *Governing the Commons* (E. Ostrom 1990). It was the subject of work she and I co-authored, and the subject of my Ph.D dissertation and several publications from the 1980s through the 2000s. It was the subject of Brian Steed's Ph.D. dissertation completed in 2010 and work he published before and since.

The Ostrom Workshop experience and perspective is going to be valuable and essential to this work. Governing and managing the groundwater basins in California that have to comply with SGMA will necessarily entail polycentric structures, the development of well-functioning local public economies, and rules for sustaining a threatened natural resource. The institutional grammar approach (Crawford and E. Ostrom 1995) is already key to coding cases of existing groundwater management arrangements.

Research Design

Colleagues at Stanford and I are beginning to review and code the institutional grammar the governance and management arrangements in 15 institutionally diverse California groundwater basins. These are basins that Workshoppers have not researched previously and therefore will add to our knowledge base on this subject. We are coding those institutional arrangements in relation to the requirements and powers delineated in SGMA. An early draft of one example is included as an appendix at the end of this paper.

Comparative analysis of these coded data will allow us to determine which existing arrangements come closest to satisfying the specifications of SGMA and which appear to have come closest to success in meeting goals of bringing overdrafted groundwater basins back into balance. We will then develop workshops and training instruments for sharing these research results with individuals and local governments as they attempt to construct governance and management arrangements in currently unmanaged basins in the state.

The coding effort is part of a broader program of research on SGMA being led by Stanford's Woods Institute on the Environment, together with the Stanford Law School's Gould Center on Dispute Resolution. The research is organized under five themes:

- The interaction between legal standards, property rights, and groundwater allocation
- Design of pre-SGMA arrangements for managing groundwater
- Performance and effectiveness of pre-SGMA arrangements
- Role that scientific information and analytic models played in developing and maintaining groundwater management arrangements
- Resilience and adaptability

The study focuses on 15 cases:

- the seven basins that have been adjudicated since 1990 – Mojave, Santa Paula, Six Basins, Beaumont, Seaside, Santa Maria, and San Jacinto;
- five special act districts that were selected using a matching approach, where districts in similar locations were eliminated – Zone 7 Water Agency, Desert Water Agency, Fox Canyon Groundwater Management Agency, Pajaro Valley Water Management Agency, and Santa Clara Valley Water District;
- Sonoma County and Sacramento Groundwater Authority, two negotiated agreements commonly cited as successful examples of planning under AB3030; and
- Glenn County, the first example in CA of using general police powers to manage groundwater.

[Note: we may consider adding Inyo County as an example of the use of CEQA for groundwater management.]

A combination of methods will be used: (a) coding and analyzing documents, including court and legislative records, newspapers, and other relevant documents; (b) interviews with past and current groundwater managers, lawyers and potentially judges; and (c) quantitative analysis of groundwater data in case basins before and after a management regime was implemented.

Theme 1: The interaction between legal standards, property rights, and groundwater allocation in California

Research questions:

- What legal precedents have guided post-1990 adjudications?
- How have these standards affected the way cases are litigated and settled?
- Has uncertainty over legal rules affected parties' negotiating behavior or made cases more difficult to resolve?
- What are the implications for future adjudications that emerge in the context of SGMA?

Relevance to SGMA implementation

SGMA explicitly leaves groundwater property rights unchanged, potentially creating incentives for parties unsatisfied with groundwater plans to pursue adjudication through the courts. Adjudication, however, may also have uncertainties of its own, as the legal standards for court decisions about groundwater allocation have not always been predictable. In particular, in its review of the Mojave decision in 2000, the California Supreme Court found that despite the complexity involved in determining groundwater rights, courts may not impose an equitable apportionment of rights without first defining and prioritizing them individually. In particular, courts must recognize the priority of overlying users, and their rights must be protected to the extent that their water use is beneficial and reasonable. Yet, the need to fully define and prioritize rights may make it more difficult to reach a judgment in a timely manner, and overlying users have little incentive to come to the table. To date, there have been few analyses of the legal arguments and standards employed in recent adjudications. This research would help to fill this gap, and provide insight into the role of the courts in resolving conflicts that emerge in the context of SGMA.

Key themes for coding

- How have post-1990 adjudications defined and prioritized rights? What uncertainties remain in the legal standards for doing so?
 - What has been the influence of the Mojave decision on these cases?
 - What other legal precedents have played an important role in shaping post-1990 adjudications?
- Has the need to define individual rights and prioritize overlying rights slowed the adjudication process, or otherwise made it difficult to reach an agreement that promotes sustainable management of a groundwater basin?
- What strategies have been employed to reduce complexities in defining rights, and in providing incentives for overlying users to participate in an agreement?
- What role does the recent legislation for streamlining the adjudication process play with respect to these issues?

Key sources

- Review of existing literature
- Judgments, complaints and other legal documents (analyze judgments and other available documents first; then identify if additional legal documents are needed).

Focus on our seven adjudication cases: Mojave (1996/1998/2000); Santa Paula (1996), Six Basins (1998), Beaumont (2004), Seaside (2006), Santa Maria (2008), and San Jacinto (2013). Los Osos (on-going) may also be useful to include.

- Interviews with key lawyers and/or judges involved in these cases

Theme 2: Design of pre-SGMA arrangements for managing groundwater

Research questions

- What factors or conditions were important in determining the design of pre-SGMA groundwater management institutions?
- How do the goals, governance structures, and opportunities for stakeholder participation in pre-SGMA arrangements compare to requirements laid out for GSAs under SGMA?

Relevance to SGMA implementation

Although it offers local agencies considerable flexibility, SGMA establishes the first statewide requirements for groundwater management in California. In many parts of the state, local agencies are grappling with the creation of new governing bodies that, for the first time, may exercise authority to control groundwater extractions. These new Groundwater Sustainability Agencies (GSAs) must meet SGMA's specific requirements with regard to how sustainability is defined, the authorities that the GSA may hold, and the breadth of stakeholders that must be engaged in the process. Yet, SGMA is being implemented in the context of pre-existing institutional arrangements for groundwater management that have evolved very differently across the state. An understanding of how California's existing local groundwater management efforts compare with SGMA's new requirements and the conditions under which they emerged can provide important insights for the formation of GSAs.

Key themes for coding

- Conditions:
 - What triggered the adjudication/Special Act/AB 3030 planning process/ordinance?
 - How did these circumstances influence institutional design?
- Goals:
 - What goals did these pre-SGMA arrangements seek to achieve?
 - How do their definitions of "safe" or "sustainable" yield compare to how sustainability is defined in SGMA (i.e., which "undesirable results" were targeted)?
- Governance:
 - Which entities (if any) hold the authorities that SGMA outlines for GSAs?
 - Did anyone have those authorities prior to the adjudication/special act/AB 3030 process? How did the adjudication/Special Act District/AB 3030 planning process/ordinance change how these authorities were allocated?
- Participation:

- Which stakeholders have participated in the governance structure established in each case? How closely does this match SGMA's list of interests that GSAs are required to engage?
- What factors have affected the nature of their participation? Do different avenues (adjudication v. special act district v. AB 3030 planning process v. ordinance) tend to offer more or less of a voice for particular stakeholders?
- Do any stakeholders or stakeholder groups have representation on basin decision-making bodies and, if so, which ones? [This is to get at the distinction between participation as input/consultation versus participation as power.]
- In practice, what has been the relative balance of power among participating stakeholders?
- Contents of groundwater management plans
 - How do groundwater management plans in our cases compare to SGMA's requirements for GSPs (would be best to code for this after GSP regs are issued)

Key sources

- SGMA (key SGMA provisions are used to guide coding on goals, governance structures and participation)
- Judgments/acts/plans/ordinances for each case
- Meeting minutes
- News articles for discussion of key events at the time the process began
- Interviews as needed

Theme 3: Performance and effectiveness of pre-SGMA arrangements

Research questions

- How successful have pre-SGMA arrangements been in meeting their intended goals?
- What management strategies appear to have been most important in affecting users' behavior?
- What management strategies appear to have been most important in affecting basin conditions?
- What capacity (authority, funding, expertise, political support) has been required to enable implementation of these strategies?

Relevance to SGMA implementation

SGMA exempts adjudications from most of its requirements, and in doing so, implicitly assumes that these court-supervised arrangements provide adequate protection against unsustainable groundwater use. Yet, adjudications vary considerably in their intended goals, and in the strategies and mechanisms they have employed to achieve those goals. A better understanding of the goals and effectiveness of adjudications is crucial to ensuring their overall sustainability and their value as examples. In addition, adjudications, special act districts, and several exemplary AB3030 plans may offer important insights into which management strategies have

been effective in the past, and the conditions needed to implement them. Finally, an analysis of the capacity that has been needed for pre-SGMA arrangements to be effective in managing local groundwater resources using particular strategies may provide valuable information for emerging GSAs and for state policymakers monitoring the effectiveness of SGMA implementation and considering whether changes are needed.

Key themes for coding

- Assessing performance:
 - How was performance intended to be measured in each case (build upon coding about goals under Theme 2)
 - To what degree have pre-defined goals been achieved?
 - Have original goals changed over time? (may relate to Theme 5)
- Groundwater management strategies:
 - Which management strategies have been most important in achieving particular outcomes? Key approaches to explore include:
 - Groundwater replenishment (via imported water, natural recharge, recycled water)
 - Pumping restrictions
 - Water conservation
 - Water transfers or exchanges
 - Carryovers
 - Groundwater storage programs
 - Use of fees as an incentive to reduce pumping
 - Groundwater monitoring
 - Has the mix of strategies changed over time and, if so, in what ways?
 - What conditions (hydrologic, institutional, socio-economic, resource) have been important for enabling implementation of these strategies?
- Capacity:
 - What resources (financial, organizational, technical) have adjudications, Special Act Districts, AB 3030 and county ordinances utilized to conduct groundwater management activities?
 - How did the specific socio-economic and institutional context (i.e., rural v. urban, history of previous collaboration regarding water management) shape the capacity that emerged in each case? [This might remain here, or move to Theme 5.]
 - What levels and kinds of capacity are needed to implement particular types of groundwater management strategies?

Key Sources

- Judgments, acts, groundwater management plans, ordinances
- Organizational and budget documents for entities responsible for groundwater management
- Project documents and technical studies
- Quantitative data available in annual reports regarding performance indicators such as changes in groundwater levels, water quality, subsidence, etc.

- Interviews as needed

Theme 4: Roles of scientific information and analytic models in groundwater management arrangements

Research questions

- What roles have technical information and groundwater models played in the process of negotiating and implementing pre-SGMA arrangements?
- Under what conditions does technical information gain meaning, such that it becomes the basis for decision-making?

Relevance to SGMA Implementation

Effective groundwater management depends heavily upon technical data and models to understand groundwater conditions and identify appropriate management actions. In California, data about groundwater conditions is often limited and uncertain, due to inadequate monitoring as well as the complex dynamics of aquifers and their interaction with surface water. Even when data is available, determining how it should be utilized in decision-making and building trust in data sources across diverse interests is often challenging. In the context of SGMA, all GSAs are required to develop Groundwater Sustainability Plans (GSPs) that avoid “significant and unreasonable” levels of six undesirable results. In defining what constitutes “significant and unreasonable,” GSAs must identify specific thresholds for each undesirable result that would trigger management actions, and agree upon the data that will be used to assess whether a threshold has been reached. Forthcoming regulations from the California Department of Water Resources (DWR) may provide some guidance on data sources that can serve as common references, but each GSA will need to define what thresholds are “significant and unreasonable.” An exploration of the role of technical data and models in pre-SGMA arrangements, as well as an examination of case studies in which specific data has acquired meaning as indicators that drive decision-making, will provide useful insights as GSAs face these challenges.

Key themes for coding:

- Technical information and institutional design (relates to Theme 2, question 1):
 - What data/models were available when the institution was designed? How was it communicated to parties involved? (Code by undesirable results in SGMA, types of information, spatial/technical coverage, extent it meets SGMA requirements for post-GSP annual reporting)
 - Were there debates about the condition of the basin and the nature and/or severity of the problems at hand? How were these debates resolved?
 - What role did technical information play in catalyzing the formation of the management regime? Were there key uncertainties that drove activities?
- Data and models in on-going management:
 - What is the process for gathering and analyzing technical data (including groundwater monitoring activities)? How are consultants, staff, and

- stakeholders involved? What data management tools does the agency use? What resources are required? Are there tools the agencies wish they had?
 - What models are used for ongoing management? Who runs them, how are stakeholders engaged, and how are results shared?
 - What roles have monitoring and models played in the choice and implementation of groundwater management strategies?
 - Role of data in decision-making:
 - Are any decisions about management actions triggered by specific thresholds or indicators? What data is used, and what process was involved to generate agreement around action based on these data?
 - With respect to specific groundwater problems that are intended to be addressed in each case, how has progress been assessed?
 - How were data sources chosen, and how do these compare with the data sources that SGMA requires GSAs to collect and report?

Key sources

- Judgments, acts, plans, and ordinances, and technical studies associated with them
- Documents related to groundwater monitoring plans
- Documents related to groundwater models and their use
- Annual reports and other documents that discuss decisions made and data used to justify them
- Interviews

Theme 5: Resilience and adaptability

Research questions:

- How resilient have pre-SGMA groundwater management arrangements been with respect to droughts and other crises?
- To what degree, and in what ways, have pre-SGMA arrangements explicitly taken climate change into account?

Relevance to SGMA Implementation

The impacts of climate change on water resources in California are expected to be significant, including on groundwater resources. Decreased snowpack and earlier or faster snowmelt will affect groundwater recharge, sea level rise will exacerbate seawater intrusion, and increased frequency and severity of droughts will likely result in increased demands on groundwater. GSPs developed under SGMA must plan based on a 50-year time horizon, within which many of these impacts are likely to be felt. Forthcoming regulations for GSPs will require that GSAs take climate change into account in some way, although it is not yet clear how specific the regulations will be about how to do so. Assessing how resilient pre-SGMA arrangements have been to drought and other crises, and the degree to which they do (or do not) already consider climate change impacts in their planning will be important for informing how GSAs comply with requirements to consider climate change under SGMA.

Key themes for coding:

- Climatic assumptions
 - What assumptions about future climate and precipitation were relied upon in creating the management arrangement (e.g. timing of runoff, amount of annual recharge)?
- Resilience in response to crises (droughts, also floods or other extreme weather events)
- Was the management arrangement designed with specific provisions that govern the response to drought or extreme weather? (e.g. rights defined as percentage rather than amount)
- How have these management strategies (either a priori or designed on the fly) performed in the context of droughts or other crises?
- Have changes been made to governance structures or management strategies that improve (or erode) capacity to cope with extreme droughts, and what factors help drive these changes?
- Resilience in response to non-crisis change—e.g., adaptation to changes in population, land use, economic activity, technology.
- How effective have these pre-SGMA arrangements been in adapting to changed conditions, new problems, and new opportunities?
- Provisions for future climate change (if any)
- What provisions (if any) explicitly address the possibility of a future changing climate? (possible in more recent cases)
- How flexible is the management arrangement, should it become necessary to alter it in light of a changing climate in the future?

Key sources

- Review of existing literature
- Judgments, acts, plans, ordinances
- Technical studies used in developing management plans
- Other relevant planning documents
- Interviews

A Parallel Process: Working with an Agency on SGMA Implementation Issues

Concurrently, we will communicate with agencies that are embarking on the SGMA process, in order to identify factors and problems that arise during the process of implementation but we did not anticipate in formulating our research design. We are currently in discussions with the governing boards and general managers in two basins: the Yolo County Flood Control and Water Conservation District and the Yuba County Water Agency. Both groundwater agencies are located in California's Central Valley, an area of critical importance in groundwater management in California, and have been actively involved in the development of management plans in their respective areas. As a result, each has established working relationships with neighboring water management agencies and integrate a variety of stakeholders, including large agricultural water users, municipalities, and environmental interests into their groundwater planning decisions. Finally, both

agencies have developed groundwater management plans, which are expected to serve as the basis for the sustainability plans pursuant to SGMA. These plans are supported by groundwater monitoring networks and groundwater models. Their initiation of SGMA implementation creates opportunities for them and us to identify research needs and opportunities, try out training processes and workshops, and develop decision support tools that GSAs in other basins are likely to need and find useful.

Our work will be completed at a time (2017) when local basins in the California are shifting from GSA formation to the development of GSPs. The ultimate goal of the work is to help develop tools that can be adopted directly by GSAs to develop and implement GSPs that lead to sustainable management, and that will be enforceable and durable. After all, if the Sustainable Groundwater Management Act is to succeed, it isn't just the groundwater that has to be sustainable—it's the management too.

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Appendix. Coding form in development

Revised coding scheme - Goals, participation, and authorities - Jan. 12, 2016 version, using example of Fox Canyon Groundwater Management Agency					
Bold text indicates "shall"; Regular text indicates "may"					
Element	Coding element	SGMA	Reference	Fox Canyon	Reference
Management goal	Overall objectives	Achieve "sustainability" in medium and high-priority basins by 2040/2042	10721 (u) , (v)	Balance supply and demand in Oxnard and Mugu aquifers by 2000. Achieve safe yield in lower aquifer system by 2010.	FCGMA Act, Sec. 121-601 and 121-1102
	Definition of sustainable or safe yield	Sustainable Yield: "The maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result."	10721 (v)	"Available supply" means that quantity of groundwater which can be withdrawn in any given year without resulting in or aggravating conditions of overdraft, subsidence, or groundwater quality degradation. "Safe yield" means the condition of a groundwater basin when the total average annual groundwater extractions are equal to, or less than, the total average annual groundwater recharge, either naturally or artificially.	FCGMA Act, Sec. 121-304 and 121-331

Types of impacts to be avoided	Overdraft	Yes	10721 (w)	Yes	FCGMA Act, Sec. 121-304 and 121-601
	Reduction in groundwater storage	Yes			
	Seawater intrusion	Yes		Yes for the lower aquifer system	FCGMA Act, Sec. 121-602
	Degraded water quality	Yes		Yes	FCGMA Act, Sec. 121-304
	Land subsidence	Yes		Yes	FCGMA Act, Sec. 121-304
	Depletions of interconnected surface water	Yes			
Interests represented	Overlying agricultural users	Yes	10723.2	Yes, membership on FCGMA board of directors	FCGMA Act, Sec. 121-401
	Overlying domestic well owners	Yes			
	Municipal well operators	Yes			
	Public water systems	Yes		Yes, membership on FCGMA board of directors	FCGMA Act, Sec. 121-401
	Local land use planning agencies	Yes		Yes, county appoints member to FCGMA board	FCGMA Act, Sec. 121-401
	Environmental users of groundwater	Yes			
	Surface water users (if hydrologic connection exists)	Yes			

	Federal government	Yes			
	California Native American tribes	Yes			
	Disadvantaged communities (incl. those served by private domestic wells/small CSDs)	Yes			
	Entities involved in monitoring groundwater elevations	Yes			
	Other	Yes			
Process for stakeholder involvement	Stakeholder outreach/communication	Yes. GSAs are required to: Maintain a list of all interested persons; provide a written statement of how they can participate in GSP development; and "encourage active involvement of diverse social, cultural and economic elements of the population"	10723.4		
	Advisory committee	Yes. GSAs may appoint and consult with an advisory committee in developing and implementing a GSP	10727.8		
Authorities	Conduct investigations and inspections	Yes	10725.4 (a) and (b)	Yes, may inspect any extraction facility. Yes, may conduct investigations.	FCGMA Act, Sec. 121-410 and 121-501
	Acquire, sell and manage property	Yes	10726.2 (a)		

	Acquire water rights (<i>NOTE: is this implied in buying water rights, below?</i>)	Yes	10726.2 (b)		
	Import water	Yes	10726.2 (b)		
	Undertake water storage or groundwater replenishment programs	Yes (but shall not alter existing conjunctive use or storage program except if it interferes with GSP)	10726.2 (b)	FCGMA shall not operate spreading grounds, flood control facilities or water distribution facilities	FCGMA Act, Sec. 121-402
	Buy, sell, or exchange water or water rights	Yes	10726.2 (c)	No wholesale or retail sales of water	FCGMA Act, Sec. 121-402
	Distribute or deliver water	Yes (but shall not deliver retail supplies within service area of public water system without that system's consent)	10726.2 (d)	FCGMA shall not operate water distribution facilities. No wholesale or retail sales of water	FCGMA Act, Sec. 121-402
	Treat water to improve water quality	Yes - may transport, reclaim, purify, desalinate, treat or otherwise manage polluted water, wastewater, or other water	10726.2 (e)		
	Impose well spacing requirements	Yes	10726.4 (a)(1)	Yes	FCGMA Act, Sec. 121-701(d), 121-701(e) and implied in 121-602(c)

	Limit extractions	Yes	10726.4 (a)(2)	Yes, for the lower aquifer system, once a management plan has been adopted	FCGMA Act, Sec. 121-602(d), also 121-701(b) and 121-701(e)
	Limit construction, expansion or re-activation of wells	Yes	10726.4 (a)(2)	Yes	FCGMA Act, Sec. 121-602(c) and 121-701(b)
	Establish groundwater allocations	Yes	10726.4 (a)(2)	Yes	FCGMA Act, Sec. 121-1101
	Authorize temporary or permanent water transfers	Yes	10726.4(a)(3)		
	Establish rules for carryovers	Yes	10726.4(a)(4)		
	Issue well permits	No (except as authorized by county that holds this authority)	10726.4(b)	Yes, for the lower aquifer system	FCGMA Act, Sec. 121-602(c)
	Determine water rights	No	10726.8(b)		
	Coordinate with land use plans	Yes (shall ensure consistency with general plans)	10726.9		
	Promote water conservation	Not mentioned		Yes, may require conservation practices. Yes, may encourage wastewater reuse and other water projects that will contribute to groundwater management objectives.	FCGMA Act, Sec. 121-701(a) and 121-503

	Promote voluntary fallowing of agricultural lands	Yes	10726.2 (c)		
	Exemptions for de minimus extractors	De minimus (< 2AFY) may be exempted from reporting requirements	10725.8 (e)	Yes	FCGMA Act, Sec. 121-409
	Allocate groundwater storage space	Not mentioned			
	Right to engage in legal proceedings regarding groundwater	Not mentioned		Yes	FCGMA Act, Sec. 121-406, 121-407, and 121-701(c)
Reporting	Require measuring devices	Yes	10725.8 (a)	Yes	FCGMA Act, Sec. 121-804 through 121-809
	Well registration	Yes	10725.6	Yes	FCGMA Act, Sec. 121-801 through 121-803
	Require extractors to report annual extractions	Yes (de minimus extractors exempted)	10725.8 (c)	Yes, but semi-annually or more often	FCGMA Act, Sec. 121-810 through 121-812
	Require reporting of surface water diversions to groundwater storage	Entities must report any surface water diversions to groundwater storage to the GSA	10726		

	File annual report on groundwater conditions	Filing of annual report on groundwater conditions by GSA	10728	Yes	FCGMA Act, Sec. 121-502
Planning	Prepare a groundwater management plan	Yes	10727	FCGMA will develop and adopt a plan to balance Oxnard and Mugu aquifers by 2000. FCGMA will develop groundwater management plans for the lower aquifer system.	FCGMA Act, Sec. 121-601 and 121-602
	Identify measurable goals	Yes	10727(b)(1)	Yes, groundwater storage and change in storage in the lower aquifer system	FCGMA Act, Sec. 121-602
	Update plan regularly	Yes	10728.2		
	Timeline for achieving sustainability	20 years	10727(b)(1)	2000 for Oxnard and Mugu aquifers. 2010 for lower aquifer system.	FCGMA Act, Sec. 121-601 and 121-1102(a)
	Planning horizon	50 years	10721 (q)		
Fees	Fees to support groundwater management programs	Yes	10730	Yes, within limit set by statute	FCGMA Act 121-901 fees on member agencies, 121-1001 fees on operators
	Augmentation/replenishment fees	Yes	10730(d)		

	Option to collect fees as ad valorem taxes on land parcels	Yes	10730.2	Yes	FCGMA Act, Sec. 121-1105(b)
	Penalties for over-extraction, rule violations	Yes	10730.2(d)	Yes	FCGMA Act, Sec. 121-404 and 121-405
	Authority to issue bonds	Not mentioned			
	Other			Extractions in excess of FCGMA-assigned extraction allocations may be subjected to a surcharge, for the purposes of discouraging extractions, eliminating overdraft, and achieving safe yield by 2010.	FCGMA Act, Sec. 121-1101 and 121-1102
Implementation	Coding element				
Primary management strategies employed (what has been done in practice - refer to recent basin	Obtain imported water (for recharge or in lieu use)				
	Use of local surface water/stormwater (for recharge or in lieu use)				
	Use of recycled water (for recharge or in lieu use)				
	Restrict pumping				
	Groundwater storage				

management plans, etc)	Water conservation				
	Water transfers or exchanges				
	Carryovers				
	Use of fees to incentivize pumping reductions				
	Other key strategies?				
Management entity	What kind of entity is implementing the judgment/Act?				
	What is the decision-making body, and who is represented on it?				
	What is that entity's approximate annual budget (in 2013-14, if available)?				
	Key revenue sources				