MIND THE GAPS

THE CASE FOR TRULY COMPREHENSIVE SUSTAINABLE GROUNDWATER MANAGEMENT

Barton H. Thompson, Jr., Melissa M. Rohde, Jeanette K. Howard and Sandi Matsumoto

March 2021

Stanford | Water in the West

The Nature Conservancy

Acknowledgements

The authors thank Jennifer Carah, Andrew Fahlund, Pablo Garza, Felicia Marcus, Russ McGlothlin, Tara Moran, Mike Myatt, Leon Szeptyck and Jay Ziegler for providing insightful and helpful review, and the Water Foundation for supporting the authors from The Nature Conservancy to do this work.

Authors

Barton H. Thompson is the Robert E. Paradise Professor of Natural Resources Law, a Senior Fellow of the Woods Institute for the Environment, and Faculty Director of Water in the West at Stanford University.

Melissa M. Rohde is a Groundwater Scientist at The Nature Conservancy.

Jeanette K. Howard is Director of Science for the California Water Program of The Nature Conservancy.

Sandi Matsumoto is Director of the California Water Program of The Nature Conservancy.

Recommended Citation

Thompson, B., M.M. Rohde, J.K. Howard, S. Matsumoto. 2021. Mind the Gaps: The Case for Truly Comprehensive Sustainable Groundwater Management. Water in the West. Stanford Digital Repository. Available at: **https://purl.stanford.edu/hs475mt1364**

TABLE OF CONTENTS

LIST OF FIGURES

ACRONYMS

AF
acre-feet

baf
billion acre-feet

DWR
California Department of Water Resources

maf
million acre-feet

mg/L
milligrams per liter

GCD
Groundwater Conservation District

GSA
groundwater sustainability agency

GSP
groundwater sustainability plan

SGMA
Sustainable Groundwater Management Act

SWRCB
State Water Resources Control Board

TDS
Total Dissolved Solutes

Photo credit: © Douglas Steakley

INTRODUCTION

Groundwater is the resilience in California's water supply. During periods of drought, the water stored underground provides up to 60 percent of the state's water[1], and 85 percent of Californians depend on groundwater for some portion of their water supply[2]. With climate change expected to increase the duration and severity of drought, it is imperative that California sustainably manage this precious resource.

In 2014, California took a major step toward sustainable groundwater with the passage of the Sustainable Groundwater Management Act (SGMA)[3]. Despite groundwater's crucial importance in meeting California's water needs and a long history of groundwater overdraft, the state for over a century provided no statewide management of groundwater supply. SGMA sought to change that through a combination of state mandates and local management. Unfortunately, efforts to fill regulatory holes can, intentionally or unintentionally, leave smaller regulatory gaps that continue to pose significant obstacles to effective governance yet are less obvious to the public. While a positive step forward in many respects, SGMA is an illustration of this challenge. Under SGMA implementation, three major gaps in California's regulation of groundwater pumping remain: brackish groundwater, non-alluvial groundwater basins (e.g., fractured hard rock or volcanics) and basins ranked by the state as lower priority (Figure 1). As discussed below, these gaps can cause serious harm to communities and ecosystems, and therefore must be addressed if California truly wishes to manage its groundwater sustainably.

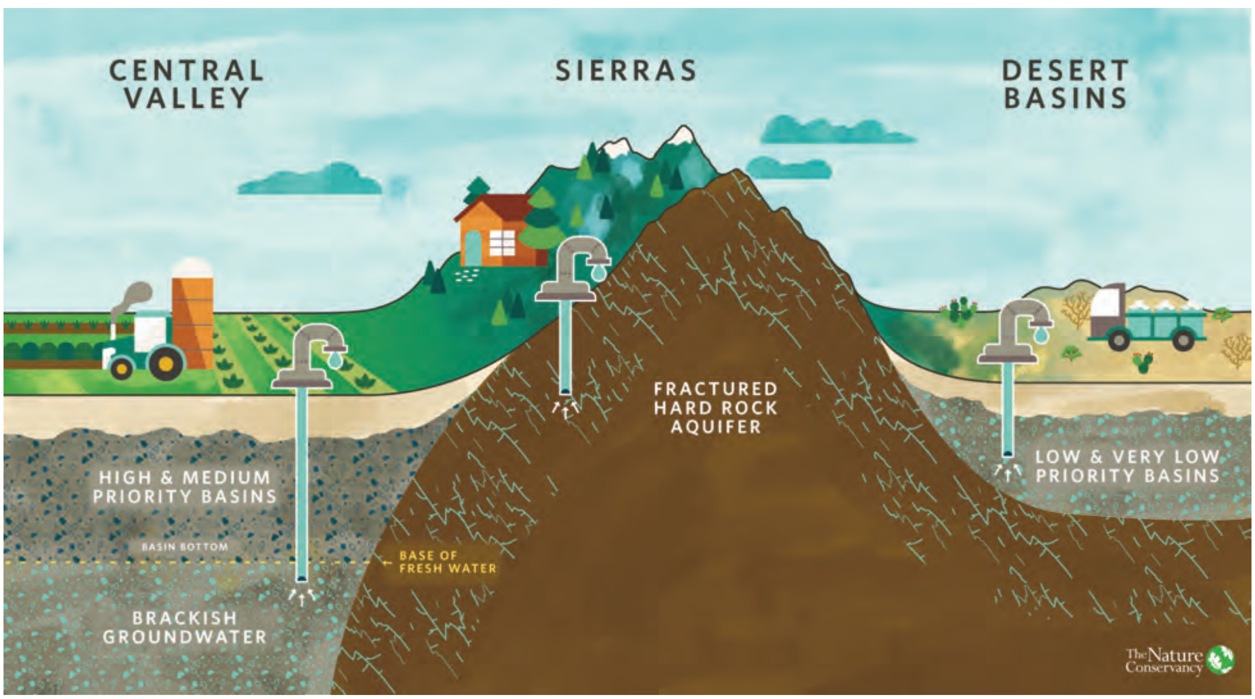

Figure 1. Regulatory gaps in sustainable groundwater management within California.

The gaps in SGMA implementation are, from left to right, (1) brackish groundwater, (2) fractured hard rock aquifers, and (3) low and very-low priority basins.

MAJOR SGMA GAPS

On its face, SGMA appears to promise comprehensive groundwater management. The legislature sought to "provide for the sustainable management of groundwater basins"[4]. SGMA therefore "applies to *all* groundwater basins in the state"[5]. Groundwater, moreover, is defined broadly as any "water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water"[6]. Because SGMA requires local regulation of each groundwater basin, SGMA had to determine the boundaries of those groundwater basins. SGMA does this by referencing Bulletin 118 – recently rebranded as "California's Groundwater" – a publication in which the California Department of Water Resources (DWR) defines individual basins[7].

Bulletin 118 immediately creates two regulatory gaps, because Bulletin 118 (1) defines only alluvial basins and does not map fractured hard rock and volcanic aquifers (which it labels "non-basin areas") and (2) does not define the basin bottom, which effectively allows local agencies to exclude lower lying brackish groundwater by defining the basin bottom as above that brackish groundwater. SGMA creates a third gap by requiring regulation only in alluvial basins that DWR ranks as medium or high priority – even though pumping in the low and very-low priority basins can lead to undesirable results, such as depletion of streamflow. DWR has ranked only 18 percent (94 out of 515) of Bulletin 118 groundwater basins as medium or high priority, although these basins account for virtually all of current groundwater pumping in the state. The result is a fragmented regulatory system that leaves significant gaps in the sustainable management of California's groundwater.

As shown in Figure 2, the volume of potentially unregulated groundwater is immense, leaving the largest volumes of groundwater in California still vulnerable to over-extraction. DWR has estimated that there is approximately one billion acre-feet (baf) of fresh groundwater storage capacity (total dissolved solutes or "TDS" <1,000 milligrams per liter (mg/L)) in the state's alluvial basins[8]. This groundwater storage estimate is dwarfed if it includes brackish groundwater that is economically viable to treat and use (TDS < 10,000 mg/L)[9], which combined totals approximately 24 baf of fresh and brackish groundwater[10]. This volume is equivalent to increasing California's surface reservoir storage capacity (50 million acre-feet) as much as 480 times. In addition to brackish groundwater, groundwater in fractured hard rock and volcanic aquifers is also unaccounted for despite its significance in supplying water to 40 percent of wells in the state[11]. We estimate that 11 baf of groundwater exist in hard rock aquifers in California[12]. SGMA, in short, is currently regulating only a very small subset (~1 baf) of California's available groundwater supply (35 baf). While some of this groundwater might be regulated outside of SGMA by adjudication decrees or local management agencies, most of it is not.

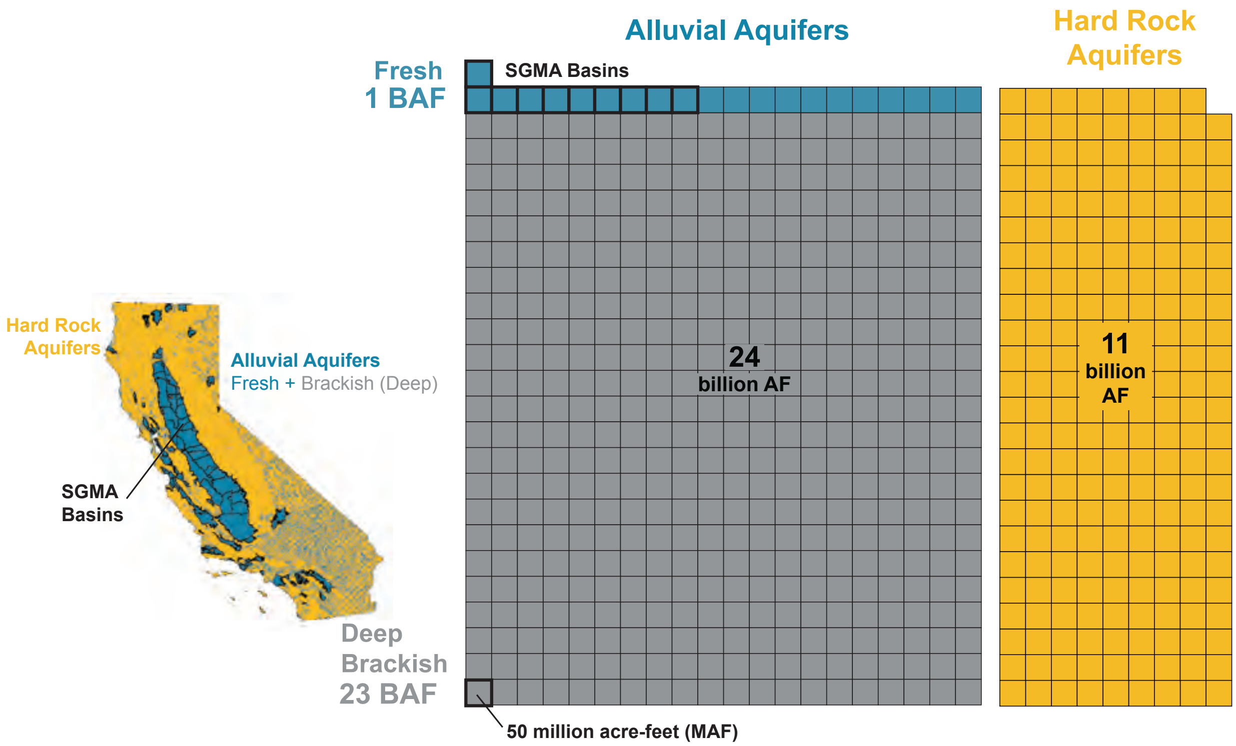

Figure 2. Estimates of groundwater storage capacity in California.

Each box represents 50 million acre-feet. Of the 35 billion acre feet (baf) of total groundwater storage capacity, 1 baf is fresh water in alluvial aquifers[8], 23 baf is brackish groundwater in alluvial aquifers[14] and 11 baf is groundwater in fractured hard rock aquifers[12]. SGMA requires regulation only of fresh groundwater in high and medium priority alluvial basins, which is less than two percent of groundwater in the state. As this chart shows, a large proportion of California's groundwater remains unregulated under SGMA.

The California legislature may have left some gaps in SGMA's coverage for political or practical reasons. However, by regulating some but not all groundwater, SGMA makes the remaining gaps more problematic. Regulation of only a portion of California's groundwater creates greater pressure on unregulated groundwater. For example, if groundwater users are unable to pump freshwater in a basin, they may turn to unregulated brackish groundwater. Improved technology has made desalination and use of brackish groundwater increasingly cost effective and feasible. Constraints on groundwater pumping in a regulated basin, moreover, can incentivize businesses or developers to move to other unregulated basins. The resulting pressure on the unregulated regions can lead to overdraft and accompanying problems, including loss of drinking water access to rural households, depletions in hydrologically connected surface water (potentially harming fish, wildlife and downstream water users), surface subsidence, desiccation of groundwater-dependent ecosystems and desertification of overlying land, which can increase wildfire risk. In short, when regulations are not comprehensive, the problem sought to be solved can translocate from regulated to unregulated regions.

By solving part, but not all, of the groundwater problem, SGMA also makes it more difficult to muster the political will needed to close the gaps. SGMA passed because the public recognized that California's failure to regulate groundwater statewide was leading to major societal problems, such as subsidence compromising public infrastructure and the loss of drinking water access to communities, which demanded correction. Because SGMA says that it regulates "all groundwater basins in the state," most of the public reasonably assumes that the problem of groundwater management in California has been solved. Unfortunately, this is not the case, yet because SGMA was so difficult to pass, there is little interest in addressing the gaps left after SGMA. Closing those gaps therefore requires educating the public on the importance of the gaps and the critical need for their closure.

Brackish Groundwater

In recent years, brackish groundwater has been increasingly used in California by either blending it with freshwater to dilute salinity or through desalination. Desalinating groundwater is often now economically viable given technological advances and the lower salt content in groundwater compared to ocean water. Based on local decisions on how the basin bottom is mapped, SGMA applies primarily to fresh groundwater and often does not apply to deep, brackish groundwater.

Photo credit: © Kelly M. Grow/ California Department of Water Resources

SGMA provides for the management of groundwater "basins" by local agencies[15], and "basins" are defined as those "identified and defined in Bulletin 118"[16]. While Bulletin 118 sets out the horizontal extent of these basins based on geologic, hydrologic and jurisdictional considerations publicly vetted by DWR, it did not delineate the basin bottom. As a result, the local Groundwater Sustainability Agencies (GSAs) established under SGMA are responsible for delineating the basin bottom and given discretion in doing so.

In the Central Valley, state and local officials generally assume that freshwater is underlain by a single plane of brackish water that is a remnant of conditions when the valley was an ocean floor in the geologic past. However, this assumption is not universally true as freshwater can be found beneath brackish aquifers[10]. To map the basin bottom, agencies commonly rely upon groundwater salinity data to map the extent of freshwater, also known as the "base of freshwater"[17]. The basin bottom is often delineated as the 'usable' bottom of the alluvial aquifer, which is based on the state's regulatory drinking water standard of 1,000 mg/L of total dissolved solids[9], or on base-of-freshwater maps published nearly 50 years ago by the U.S. Geologic Survey[18]. These decades-old base-of-freshwater maps are problematic because salinity gradients change over time and space, especially when pumping occurs. Recent research has found that wells exist deeper than these base-of-freshwater maps, suggesting that some of these wells may exist outside the defined basin and SGMA regulations[10].

DWR's Best Management Practices for the Sustainable Management of Groundwater explicitly notes that "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions"[19]. Yet approximately 60 percent of the GSAs in critically overdrafted basins have ignored this recommendation and used the outdated US Geologic Survey maps in their mandated Groundwater Sustainability Plans (GSPs)[10]. Delineating the vertical extent of groundwater basins using the base of freshwater vastly underestimates the amount of groundwater that is usable. Mapping basin bottoms with base-of-freshwater maps can also undermine a GSA's ability to achieve sustainability under SGMA because deep, brackish groundwater pumping can contribute to undesirable results in the basin such as land subsidence, reduced groundwater storage or deteriorated water quality[20]. In the absence of comprehensive well metering, many GSAs are able to use their monitoring network only to identify that undesirable results are occurring, and lack the ability to pinpoint which wells are causing undesirable groundwater conditions in the basin. Even if deep, brackish groundwater pumping wells were identified as causing an undesirable result in the basin, it is possible that those undesirable results could escape SGMA regulation since the pumping would occur outside of the defined basin boundary. A GSA can prevent this problem and protect its basin's sustainability by following DWR's best practices of ensuring that the basin bottom be at least as deep as the deepest well[19].

Fractured Hard Rocks & Volcanics

Groundwater exists in the pore space of soils and rocks. However, groundwater in fractured hard-rock and volcanic geologic formations, typically found on the slopes of mountain ranges across the state, are not mapped as groundwater basins under Bulletin 118 and, hence, are excluded from SGMA. In California, approximately 40 percent of all wells exist in these formations, which provide for a significant water supply for rural residential drinking wells, forest and aquatic ecosystems, as well as for recharge to alluvial groundwater basins in the valley floor[11]. Hard-rock aquifers are vulnerable to overdraft because groundwater extracted from the pore spaces of hard-rock and volcanic aquifers are generally three times smaller than in large alluvial aquifers[13, 21], causing groundwater extractions to draw down groundwater levels and storage faster in hard-rock aquifers than in alluvial aquifers.

While many of the wells in hard-rock and volcanic aquifers extract only small amounts of groundwater[22], wells can intercept flow destined for streams, forest ecosystems and connected alluvial basins. When pumping rates are too high, particularly during drought when precipitation cannot replenish groundwater in the system, the cumulative impact of these small wells can cause significant negative impacts such as depleted streamflow, reduced recharge into connected basins and reduced access to drinking water when wells dry out[23, 24]. Because many of these upstream aquifers provide source water for alluvial basins, shifts in pumping to these aquifers may also impact the ability of GSAs to meet SGMA goals in regulated alluvial basins.

When groundwater levels decline in hard-rock aquifers, wildfire risk can also increase if forests lose access to critical water reserves needed to mitigate water stress during drought. For example, prolonged dry conditions between 2012 and 2016 caused water stress in trees such as ponderosa pine, lodgepole pine and Douglas fir by depleting groundwater reserves that typically buffer trees over multi-year dry periods[25-27]. The prolonged water stress increased the trees' susceptibility to bark beetle infestation, resulting in more than 100 million dead trees in the Sierra Nevada Mountains[28]. This tree mortality contributed to California's destructive and deadly wildfire seasons in 2017 and 2018, with a combined 3.5 million acres of land burned and nearly 150 fatalities[29]. This increased wildfire risk, in turn, poses significant risks to people's homes, air quality and forest ecosystems, and it releases stored carbon into the atmosphere, exacerbating climate change.

Low & Very-Low Priority Basins

While SGMA authorizes the sustainable management of all Bulletin 118 groundwater basins, it requires the development and implementation of a GSP only for those basins categorized by DWR as high or medium priority[30,31]. While California law requires DWR to consider a variety of factors in prioritizing groundwater basins, including the degree to which existing pumping is leading to undesirable impacts such as "impacts on local habitat and local streamflow"[32], DWR has based its ranking primarily on the degree of human groundwater use, using proxies such as population, number of wells, irrigated acreage and the degree to which people rely on groundwater as their primary source of water. DWR ranked the least utilized basins as low or very-low priority, leaving them outside SGMA regulation. These low and very-low priority basins include much of the Mojave Desert and the North Coast.

Given the Herculean task of preparing detailed GSPs, such prioritization may frequently make practical sense so as not to over-burden basins with little to no resources for groundwater management. In practice, however, SGMA's prioritization scheme, combined with DWR's implementation, suffers from at least two problems. First, the prioritization system frees many groundwater basins that need close governance from regulatory oversight. Although they face lower pumping pressures, some low or very-low priority basins can be unsustainable even at low levels of pumping. In the case of desert regions, for example, a large majority of groundwater is of ancient origin, and low precipitation provides little in the way of annual recharge. As a result, even small amounts of groundwater pumping can threaten aquifers and the fragile ecosystems that are dependent on them; once depleted, such aquifers take far longer to replenish.

Second, SGMA's prioritization system can allow groundwater basins that so far have been relatively healthy to slip into problems. Not long ago, groundwater conditions in high and medium priority basins were similar to many of today's low or very-low priority basins. SGMA contemplates that priorities will be updated (giving local basins additional time after "reprioritization" to form a GSA and meet GSP requirements[33]). However, neither SGMA nor DWR requires automatic periodic updates, so any reprioritizations are likely to be reactive rather than proactive. Groundwater basins can begin to suffer from overpumping and related ill effects long before they meet the requirements of medium or high priority basins. Hydrological connections between groundwater basins and surface streams or groundwater-dependent ecosystems, for example, can be lost at early stages of pumping stress.

Cannabis is an emerging threat to unregulated groundwater

In the absence of SGMA, the legalization of cannabis cultivation is placing new pressures on groundwater and surface water resources needed to irrigate the crop in low and very-low priority basins, such as in the desert and North Coast basins.

View of Chicago Valley in winter (2015) showing green creosote scrub in foreground, a strip of brown mesquite bosque in the midground, and the Nopah Range in the distance.

DESERT | Under Chicago Valley in the heart of the Mojave Desert – the driest region of North America – lies the Middle Amargosa Valley sub-basin, which is ranked by DWR as a very-low priority groundwater basin. Shallow groundwater levels support honey mesquite habitat and perennial flow into the Amargosa National Wild and Scenic River. In 2019, a large industrial cannabis operation proposed to develop these groundwater resources for irrigation. To limit the impacts of this project, The Nature Conservancy acquired key properties in Chicago Valley to ensure that groundwater is not extracted and prevent groundwater depletion from adversely impacting important groundwater-dependent habitat and river flows. Unfortunately, since approximately 1.7 million acres of sensitive desert groundwater-dependent ecosystems exist in California – including thousands of acres of rare aquatic and riparian habitat – land acquisition and protection alone cannot be relied upon to protect groundwater resources in desert regions.

Photo credit: © Bridget Besaw

NORTH COAST | The North Coast is known for its large, perennially flowing rivers, which support threatened and endangered steelhead trout and salmon. Surface water was initially assumed to be the primary source of irrigation water, but groundwater is the primary water source for cannabis cultivation with 60 percent of farmers reporting groundwater use for irrigation[34]. Interim water-use regulations for legal cannabis cultivation in California prohibit surface water diversion during the dry season to protect salmonids, but do not limit groundwater use. This makes groundwater an attractive water source because pumping is not regulated by either SGMA or the State Water Resources Control Board's (SWRCB's) interim Cannabis Cultivation Policy[34,35]. Because groundwater and surface water are usually connected, groundwater pumping may reduce river flows, harming senior water rights holders and pulling water out of streams where sensitive habitat and species exist[23].

CLOSING THE GAPS

Multiple levels of government can help to close gaps in the sustainable management of California's groundwater. As explained below, SGMA already contains much of the authority needed to ensure comprehensive management – either by state or local agencies. If state or local agencies do not adequately address the problem, however, the legislature should step in to ensure the sustainable management of all California groundwater. Not only are additional steps necessary as a matter of policy, in many cases the public trust doctrine requires them[36].

State Administrative Actions

As noted at the outset, SGMA's broad statement of intent and coverage suggests that the legislature intended SGMA to be a comprehensive solution to California's groundwater sustainability problems. SGMA applies to "all groundwater basins in the state," and there is no specific exemptions of brackish groundwater or non-alluvial basins. These gaps emerged not as the result of explicit provisions in SGMA, but in most cases, from administrative decisions on how groundwater basins are defined in Bulletin 118. While the legislature mandated GSPs only in medium and high priority basins, the new groundwater management powers that SGMA provides to local governments extends to all basins. The legislature, in short, sought to provide the means of protecting all groundwater in the state from unreasonable impacts, even if for practical and political reasons it mandated the preparation of detailed GSPs only for medium and high priority basins. While specifying the factors that DWR should consider in categorizing the priority of a basin, moreover, the legislature did not set a particular formula – leaving to DWR's educated discretion how best to prioritize individual basins.

DWR therefore enjoys significant authority to mitigate or eliminate gaps that currently exist in California groundwater management. DWR can start by scrutinizing the manner in which GSAs define their basins to ensure that GSAs manage both freshwater and brackish groundwater in their systems where appropriate. As noted earlier, DWR has provided best practices that require the "definable bottom" of each basin be "at least as deep as the deepest groundwater extractions," and should ensure that all basin definitions comply with this standard[19]. Public comment letters highlighted this deficiency in many GSPs, and DWR has the authority to review and to require GSAs to correct the deficiency.

DWR should also consider defining fractured hard rock and volcanic aquifers (what DWR labels "non-basin areas") as groundwater basins in Bulletin 118. Bulletin 118 historically focused on alluvial groundwater basins because that was where most well production occurred[37]. As explained above, increased pumping and growing threats to fractured rock and volcanic aquifers now frequently call for greater management. DWR's draft update to Bulletin 118 recognizes the "local significance" and "growing number of wells" in such areas and concludes that "[a]dditional investigation, data evaluation, and management is likely needed to ensure future sustainable supplies of fractured rock non-basin groundwater for all users"[37]. While defining groundwater basins within such areas is complicated, DWR should examine whether basins could be defined in these areas via geologic maps or watershed boundaries.

DWR can help reduce the problems produced by basin prioritization in at least two separate ways. First, DWR should consider changing its prioritization formula to increase the priority of basins in low population areas, such as deserts, that face significant threats from harmful overdraft. To account for desert basins with low recharge rates, for example, DWR might strongly weight pumping levels that exceed a threshold based on the recharge rate. Second, DWR should consider providing for the periodic review of basin priorities to ensure that changes in prioritization are proactive and not just reactive. Currently, DWR states that it will review basin prioritization only when Bulletin 118 boundaries are updated. Instead, DWR could, for example, provide for automatic priority reviews every five years. DWR also might consider establishing a petition process by which non-governmental organizations and others could request DWR to review the priority assigned to a particular basin where changed circumstances or emerging threats suggest a need.

As part of a more proactive process, DWR and SWRCB should also sponsor the development of accessible numerical and analytical models that state agencies, counties and consultants can use to assess groundwater pumping impacts of new wells on surface water, ecosystems and other existing wells. And to address potential streamflow depletions associated with groundwater pumping for cannabis cultivation, SWRCB may want to consider additional groundwater protection or mitigation measures in its development and adoption of a permanent Cannabis Cultivation Policy. If SWRCB does not have adequate authority, the legislature might want to provide it.

Photo credit: © Ron Gilbert, Flickr

Local Administrative Actions

Local agencies also can help cure the remaining gaps in California's system of sustainable groundwater management. GSAs, for example, can define their basins to include brackish groundwater where appropriate. SGMA, as noted already, does not exclude brackish water from its definition of groundwater, and the best practice in defining the bottom of a basin is to define it to be at least as deep as the deepest groundwater wells[19].

SGMA also authorizes, even if it does not mandate, the creation of local GSAs for low and very-low priority basins. Counties and other local entities therefore can seek authorization as a local GSA, after which they can exercise the panoply of powers awarded GSAs under SGMA. Even counties and other local agencies overlying non-alluvial basins not identified in Bulletin 118 can exercise powers created through other state legislation, such as the California Groundwater Management Act (AB 3030)[38].

Where justified, local governments might wish to use their authority to provide for groundwater management equivalent in scope and goals to GSPs in medium and high priority basins. Even if current conditions do not require comprehensive management, moreover, local governments can use their authority to take important interim steps, including:

- Collecting of data to evaluate local groundwater conditions and to implement groundwater management quickly when needed. Local governments, for example, can require the collection and public disclosure of all existing and new wells, including location, geology and water-quality data. Local governments can also require the metering of all non-*de minimis* wells.
- Conducting regular groundwater analyses to identify unsustainable practices before they cause serious injury.
- Before issuing new well permits, ensuring that pumping impacts will not cause significant harm to existing groundwater users (including the environment) or deplete surface water[39]. For example, before issuing new building or well permits for agriculture, large-scale residential or commercial developments, local governments might require the developers to demonstrate that groundwater will be reliable and accessible for the proposed use over the long term and that the necessary pumping will not impact existing uses and users[40]. The development of web-based decision-support tools, such as analytical groundwater-surface water models[41], could equip county staff to improve the administrative process so that potential pumping impacts are considered.

- Enactment of permitting rules designed to avoid the most likely local impacts, particularly to local surface water uses. Local governments, for example, could utilize appropriate groundwater modeling, including analytical approaches such as the stream-depletion equation, to assess and limit the impacts of proposed wells near natural waterways[23, 41]. Local governments could also establish pumping setbacks from streams to protect surface water rights and sensitive habitats or adopt well-density limits similar to building-density limits common in land-use planning and zoning.

New State Legislation

The California legislature ultimately might need to amend or supplement SGMA to close problematic gaps. In some cases, the legislative correction might be simple and direct – e.g., legislation requiring that basins be defined to include brackish groundwater where pumping extends below the freshwater level or mandating improved prioritization of groundwater basins. In other cases, however, the legislature might need to develop new approaches to comprehensively protect California's groundwater.

As noted earlier, the identification and definition of non-alluvial basins may often be technically complex. The legislature therefore might wish to provide for groundwater management through a different geographical scheme such as by watershed rather than by basin. Given some of the technical complexities in non-alluvial basins, the legislature might also want to provide different management rules for non-alluvial basins than SGMA requires for alluvial basins; in particular, it might want to fit management rules to the nature of the problem. As suggested earlier, for example, the legislature might require that non-alluvial basins adopt plans that include data-gathering (e.g., permitting and even metering for non-*de minimis* uses) and basic, easy-to-administer permitting rules for avoiding serious impacts (e.g., well-density limits and setback rules near streams or sensitive habitats).

The legislature might also adopt a new tiered-priority system for managing groundwater basins. SGMA currently employs a binary approach: medium and high priority basins must prepare and implement GSPs, while low and very-low priority basins need do nothing (although they enjoy the authority to engage in sustainable management). The legislature instead could require basins to adopt different scopes of management based on each basin's priority. All basins, for example, might need to adopt permit systems and perhaps even metering for non-*de minimis* wells. SGMA would still require all medium and high priority basins to adopt GSPs. The new law could require low-priority basins to adopt simplified plans that identify the major threats facing the basin and actions to specifically monitor and, when necessary, address those threats. Very-low priority basins might need only carefully monitor groundwater conditions and require approval of groundwater development proposals to evaluate potential impacts.

PUBLIC TRUST RESPONSIBILITIES

As the California Court of Appeals has ruled, the state has an obligation to manage groundwater extractions that might negatively impact the environment of navigable surface waters[36]. The public trust doctrine in California protects such waters and requires the state to ensure that groundwater production does not harm those waters. Where groundwater pumping poses such a threat, all agencies of the state have a legal obligation to address and mitigate that threat. The gaps that remain in the sustainable management of California groundwater therefore not only pose a policy challenge but, in some cases, also trigger a public-trust obligation. Because all citizens of California have a right to sue to enforce the public trust doctrine, moreover, the failure to eliminate gaps that threaten navigable surface waters also poses a legal risk to the state and its agencies. Local agencies might want to act to address the gaps on their own to avoid public-trust lawsuits, as well as to avoid liability under the Endangered Species Acts or other federal and state environmental statutes.

Photo credit: © Jeanette Howard

LEGAL GAPS ALSO EXIST OUTSIDE CALIFORNIA

The remaining gaps in the sustainable management of California groundwater are not unique to California[42]. Few states, for example, have clear rules for the management of brackish groundwater, perhaps because sizable use of brackish groundwater is a recent phenomenon in most states. Texas makes the greatest use of brackish groundwater and, like California, relies largely on local management of groundwater. Texas' authorization of local management is silent on the management of brackish groundwater. Some of that state's Groundwater Conservation Districts (GCDs) largely exclude brackish groundwater from their normal production limits (e.g., the Coastal Plains GCD), while others apply special permitting rules designed to protect the freshwater portion of the aquifer (e.g., the Evergreen Underground Water Conservation District). The great majority of GCDs in Texas, however, are silent on whether, if at all, they manage brackish groundwater.

California also is not alone in utilizing some form of prioritization system in its management of groundwater. While some states manage comprehensively, others provide for the special management and protection of critically threatened groundwater basins that are determined either legislatively or administratively[43]. Other basins in those states are relegated to protection under the common law. While careful prioritization can make sense when there are scarce regulatory resources, prioritization also can open the door for unsustainable pumping of unmanaged basins.


Photo credit: © Jeanette Howard

CONCLUSION

A truly resilient and sustainable water supply will be possible in California only when all groundwater is adequately protected from overpumping. Not long ago, California was the only state in the American West without statewide groundwater regulation. Today California is beginning the difficult work of sustainably managing groundwater after decades of excessive pumping.

Over the past five years, local and state agencies in California have made incredible progress in understanding groundwater conditions and the problems that overdraft can cause. GSAs are developing groundwater sustainability plans and already implementing some. These plans are defining limits on groundwater pumping and identifying specific projects and actions to help replenish aquifers and reduce groundwater demand.

The push towards sustainability is also creating pressures and incentives to identify new sources of unregulated water, threatening unmanaged groundwater sources. This frequently includes brackish groundwater, groundwater in fractured hard rocks and/or groundwater in low and very-low priority basins. As the discussion and case studies above make clear, these important groundwater sources are often already vulnerable to groundwater pumping. Unregulated pumping has the potential to exacerbate threats to drinking water, increase wildfire risk, and compromise surface water rights and ecosystems.

But the trajectory towards these outcomes can be avoided if California acts now.

A statewide policy ensuring sustainable management of all groundwater is needed to ensure that Californians have a resilient water supply. Until appropriate statewide mandates are in place, local and state agencies have a number of existing authorities that they can and should employ to fill the gaps under SGMA and help prevent overdraft from translocating from overdrafted basins, such as the Central Valley, up to the unregulated areas, such as the Sierra foothills.

To secure a resilient water supply, California needs sustainable groundwater management, not just in current SGMA basins, but across the state.

ENDNOTES

1. California Water Boards. 2018. Groundwater Issue: Supply. Available at: *https://www.waterboards.ca.gov/water_issues/programs/groundwater/issue_supply.html*, accessed 12/16/2020.
2. Chappelle, C., E. Hanak, T. Harter. 2017. Groundwater in California. Public Policy Institute of California: San Francisco, California. Available at: *https://www.ppic.org/publication/groundwater-in-california/*, accessed 12/16/2020.
3. State of California. 2014. The Sustainable Groundwater Management Act. Available at: *http://leginfo.legislature.ca.gov/faces/codes_displayexpandedbranch.xhtml?tocCode=WAT&division=6.&title=&part=2.74.&chapter=&article*, accessed 12/16/2020.
4. Cal. Water Code § 10720.1(a)
5. Cal. Water Code § 10720.3(a) (emphasis added)
6. Cal. Water Code § 10721(g)
7. California Department of Water Resources. 2020. California's Groundwater (Bulletin 118). Available at: *https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118*, accessed 12/16/2020.
8. Groundwater Storage capacity in California's 515 alluvial groundwater basins are estimated to range between 850 million acre-feet and 1.3 billion acre-feet, based on DWR estimates.
9. We use the U.S. Environmental Protection Agency's (EPA) Underground Source of Drinking Water (USDW) total dissolved solute (TDS) concentration standard of 10,000 mg/L (as specified in Title 40, Section 144.3, of the Code of Federal Regulations) to quantify brackish groundwater volumes in California that are economically viable to treat and use. In California, brackish groundwater is considered "unusable" and defined by TDS concentrations greater than 1,000 mg/L (as specified in Title 22 State Water Resources Control Board upper secondary maximum contaminant level recommendation for drinking water). However, with technology advances and concerns with aquifer exemptions, there is a move toward increasing the TDS threshold for groundwater protection for oil and gas development from 3,000 mg/L to 10,000 mg/L.
10. Kang, M., D. Perrone, Z. Wang, S. Jasechko, M.M. Rohde. 2020. Base of fresh water, groundwater salinity, and well distribution across California. PNAS. DOI:10.1073/pnas.2015784117.
11. California Department of Water Resources. Available at *https://data.ca.gov/dataset/well-completion-reports*, accessed: January 7, 2021.
12. Groundwater in fractured hard rock aquifers were estimated across 61.5 million acres of non-alluvial basins by assuming an average porosity of 0.175 (ranges between 0.05 and 0.3 for fractured crystalline rocks and basalt[13]) and considering depths up to 1000 feet.
13. Singhal, B.B.S. and R.P. Gupta. 1999. Hydraulic properties of rocks. In: Applied Hydrogeology of Fractured Rocks. Springer, Dordrecht. *https://doi.org/10.1007/978-94-015-9208-6_8*
14. Fresh and Brackish Groundwater (TDS <10,000 mg/L) in California's 515 alluvial groundwater basins are estimated to average 24 billion AF (with estimates ranging between 8 and 40 billion AF assuming a porosity range of 0.05 and 0.25; respectively) when considering depths up to 9,000 feet[10]. Brackish groundwater (1,000 – 10,000 mg/L TDS) was estimated here by subtracting DWR's fresh groundwater estimate[8] from the average fresh and brackish groundwater estimate (24 billion AF).
15. Cal. Water Code §§ 10723(a) (providing for the creation of groundwater sustainability agencies overlying any groundwater "basin"), 10727(a) (requiring the development and implementation of groundwater sustainability plans for each medium or high priority "basin").
16. Cal. Water Code § 10721(b). See also Cal. Water Code § 10722 ("Unless other basin boundaries are established pursuant to this chapter, a basin's boundaries shall be as identified in Bulletin 118").
17. Basin bottoms can be defined based on physical properties (e.g., depth to bedrock), geochemical properties (e.g., base of freshwater, US EPA USDW standard), or field techniques (e.g., direct or indirect measurements, geophysics).
18. U.S. Geological Survey. 1973. Base of fresh ground water approximately 3,000 micromhos in the Sacramento Valley and Sacramento-San Joaquin Delta, California. Water-Resources Investigations Report: 73-40. DOI: 10.3133/wri7340.
19. California Department of Water Resources. 2016. Best Management Practices for the Sustainable Management of Groundwater: Hydrogeologic Conceptual Model. Sacramento. Available at: *https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-3-Hydrogeologic-Conceptual-Model_ay_19.pdf*, accessed January 7, 2021.
20. Withdrawing deep, brackish groundwater can drawdown groundwater levels at the fresh and brackish groundwater interface, in a process referred to as "upconing". This can translate to lowering of groundwater levels, deteriorated water quality (if upconing mixes fresh and brackish groundwater), reduced freshwater storage, and even land subsidence (if confined aquifer conditions exist) in the overlying basin.
21. The specific yield for fractured crystalline and basalt rocks range between 2 and 10 percent, and between 10 and 30 percent in sands.
22. De *minimis* domestic drinking water wells are assumed to extract less than 2 AF per year.

23. Zipper, S.C., J.K. Carah, C. Dillis, T. Gleeson, B. Kerr, M.M. Rohde, J.K. Howard, J.K.H. Zimmerman. 2019. Cannabis and residential groundwater pumping impacts on streamflow and ecosystems in Northern California. *Environmental Research Communications*, 1(12). DOI: 10.1088/2515-7620/ab534d.

24. Perrone, D. and S. Jasechko. 2017. Dry groundwater wells in the western United States. *Environmental Research Letters*, 12(10), DOI: 10.1088/1748-9326/aa8ac0.

25. Goulden, M.L. and R.C. Bales. 2019. California forest die-off linked to multi-year deep soil drying in 2012-2015 drought. *Nature Geoscience*, DOI: 10.1038/s41561-019-0388-5.

26. O'Geen, A., M. Safeeq, J. Wagenbrenner, E. Stacy, P. Harsough, S. Devine, Z. Tian, R. Ferrell, M. Goulden, J.W. Hopmans, and R. Bales. 2018. Southern Sierra Critical Zone Observatory and Kings River Experimental Watersheds: A Synthesis of Measurements, New Insights, and Future Directions. *Vadose Zone Journal*, 17:180081, DOI:10.2136/vzj2018.04.0081.

27. Klos, P.Z., M.L. Goulden, C.S. Riebe, C.L. Tague, A. O'Geen, B.A. Flinchum, M. Safeeq, M.H. Conklin, S.C. Hart, A.A. Berhe, P.C. Hartsough, W.S. Holbrook, R.C. Bales. 2018. Subsurface plant-accessible water in mountain ecosystems with a Mediterranean climate. *Wiley Interdiscip*. Rev. Water 5, e1277.

28. U.S. Forest Service. 2017. Drought and Tree Mortality in the Pacific Southwest Region. Available at: *https://www.fs.fed.us/psw/topics/tree_mortality/california/documents/DroughtFactSheet_R5_2017.pdf*, accessed: April 3, 2020.

29. CAL FIRE. 2020. Incidents Overview. Available at *https://www.fire.ca.gov/incidents/*, accessed: April 1, 2020.

30. California Department of Water Resources. 2019. Basin Prioritization. Available at: *https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization*, accessed: January 7, 2021.

31. Cal. Water Code § 10727(a).

32. Cal. Water Code § 10933.

33. Cal. Water Code § 10722.4(d).

34. Dillis, C, T.E. Grantham, C. McIntee, B. McFadin and K. Grady. 2019. Watering the Emerald Triangle: Irrigation sources used by cannabis cultivation in Northern California. *California Agriculture*, 73(3-4): 146–53.

35. The SWRCB interim Cannabis Cultivation Policy prohibits surface water diversion from April 1- Oct 31 for cannabis cultivation. In the past, cannabis growers primarily relied on riparian rights to divert surface water. However, under this policy, more cannabis growers are electing to install wells instead applying to obtain an appropriative right to divert surface water and build storage.

36. *Environmental Law Foundation v. State Water Resources Control Board*, 26 Cal.App.5th 844 (2018).

37. California Department of Water Resources. 2020. California's Groundwater Update 2020 (Draft). Available at: *https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118*, accessed March 17, 2021.

38. Cal. Water Code §§ 10750 et seq.

39. Saito, L., B. Christian, J. Diffley, H. Richter, M.M. Rohde, S.A. Morrison 2021. Managing Groundwater to Ensure Ecosystem Function. *Groundwater*. *https://ngwa.onlinelibrary.wiley.com/doi/full/10.1111/gwat.13089* DOI: 10.1111/gwat.13089

40. Los Angeles County. 2010. Potable Water Availability Requirements for Residential and Commercial Development. LA County Department of Public Health. Available at: *http://publichealth.lacounty.gov/eh/docs/ep_dw_potable_water.pdf*, accessed April 3, 2020

41. For example, see FoundrySpatial's web-based decision-support platforms, available at: *https://foundryspatial.com/solutions/*, accessed: February 8, 2021.

42. Thompson, B.H. 2011. Beyond Connections: Pursuing Multidimensional Conjunctive Management. *Idaho Law Review*, 47: 273-323.

43. Thompson, B.H., J.D. Leshy, R.H. Abrams, and S.B. Zellmer. 2018. Legal Control of Water Resources (6th ed.). West Academic.

Photo credit: © Bob Wick, Bureau of Land Management

For more information visit:
waterinthewest.stanford.edu

Water in the West
Stanford University
Jerry Yang & Akiko Yamazaki Environment
& Energy Building
473 Via Ortega, MC 4205
Stanford, CA 94305
waterinthewest@stanford.edu

Stanford | Water in the West

The Nature Conservancy