

# Chapter 26

## California's 2014 Sustainable Groundwater Management Act – From the Back Seat to the Driver Seat in the (Inter)National Groundwater Sustainability Movement



Thomas Harter

**Abstract** California's geography and Mediterranean, semi-arid climate has attracted both a burgeoning population and one of the largest irrigated agricultural developments in the world. Water resources are important to the livelihood of the state. With dry summers and highly variable annual winter precipitation, groundwater is a critical resource, drought buffer, and long-term storage reservoir for the state. Only during the most recent five-year drought, California adopted statutory control of groundwater resources: in 2014, the legislature passed the Sustainable Groundwater Management Act (SGMA). The law is the most significant California water law reform since the legislature took statutory control of surface water rights in 1914 and of water quality in 1969. This chapter provides an overview of groundwater management during the state's 150-year history, with often uncontrolled groundwater development, with conflict resolution and groundwater adjudications through the courts in some areas, and continued groundwater overdraft in others. Where courts have set limits on groundwater extraction, the objective has been to ensure stable and reliable groundwater level dynamics to avoid well outages, land subsidence, and seawater intrusion. Shortages are shared in sometimes complicated arrangements among overlying users and prior appropriators of groundwater. Under SGMA, groundwater management decisions will be made at the local level, with state oversight, to achieve long-term sustainability. We explore SGMA's vision for sustainability, stakeholder engagement, technical-scientific assessment, planning, and infrastructure practices. We also describe the role of state enforcement as a key driver for successful implementation of local groundwater sustainability plans. Importantly, local groundwater management, for the first time, will also need to consider groundwater pumping effects on surface water, on groundwater-dependent ecosystems, and on water quality. Hence, key

---

T. Harter (✉)

Department of Land, Air, and Water Resources, University of California, Davis, CA, USA  
e-mail: [thharter@ucdavis.edu](mailto:thharter@ucdavis.edu)

challenges facing local groundwater management agencies also arise from needing to address overlapping and potentially competing and less well-defined legal doctrines and federal and state laws pertaining surface water rights, ecosystems, and water quality.

**Keywords** Groundwater management · Groundwater law · Sustainability · California · Sustainable Groundwater Management Act (SGMA) · Overdraft · Land subsidence · Seawater intrusion · Water quality · Groundwater-dependent ecosystems

## 26.1 Introduction

California's semi-arid Mediterranean climate and geography share some similarities with southern Australia and southern France. Precipitation occurs almost exclusively in winter and early spring. The majority of winter precipitation is associated with just a handful of powerful storms. Hence, precipitation totals vary widely from year to year. California's landscape is dominated by the contrast between large mountain ranges (Coastal Range, Sierra Nevada-Cascade Ranges, and the Ranges of the southeast desert province) and predominantly flat, alluvial basins. The Central Valley is California's most prominent valley (47,000 km<sup>2</sup>). Like many of California's coastal basins, it is endowed with fertile agricultural soils. Rapid population and industrial growth has also occurred primarily in these central and southern California basins.

Precipitation is most abundant in California's central and northern mountain ranges. In contrast, water users are located in Central and Southern California's valleys and basins: about 4 million hectare of irrigated agricultural lands use 40 km<sup>3</sup> of water each year. Annual water consumption in urban areas – the San Francisco Bay Area (10 million people), the Los Angeles – San Diego Southern California Area (20 million people), and cities in the Central Valley (5 million people<sup>1</sup>) – amounts to 10 km<sup>3</sup>. Currently protected environmental water uses account for another 50 km<sup>3</sup> in an average year (CDWR, 2014).

California engaged from its early gold mining days in the 1850s through the 1970s in building massive water infrastructure consisting of an elaborate network of surface water storage reservoirs (40 km<sup>3</sup> combined storage) and thousands of kilometers of canals now spanning across the state. The infrastructure allows for winter precipitation (with over 15 km<sup>3</sup> as snow, Wrzesien et al., 2017) to be captured for summer water use and for water to be transferred from the rainfall-rich north to the

---

<sup>1</sup>[https://en.wikipedia.org/wiki/Combined\\_statistical\\_area#List\\_of\\_Combined\\_Statistical\\_Areas](https://en.wikipedia.org/wiki/Combined_statistical_area#List_of_Combined_Statistical_Areas), accessed 18 December 2018.

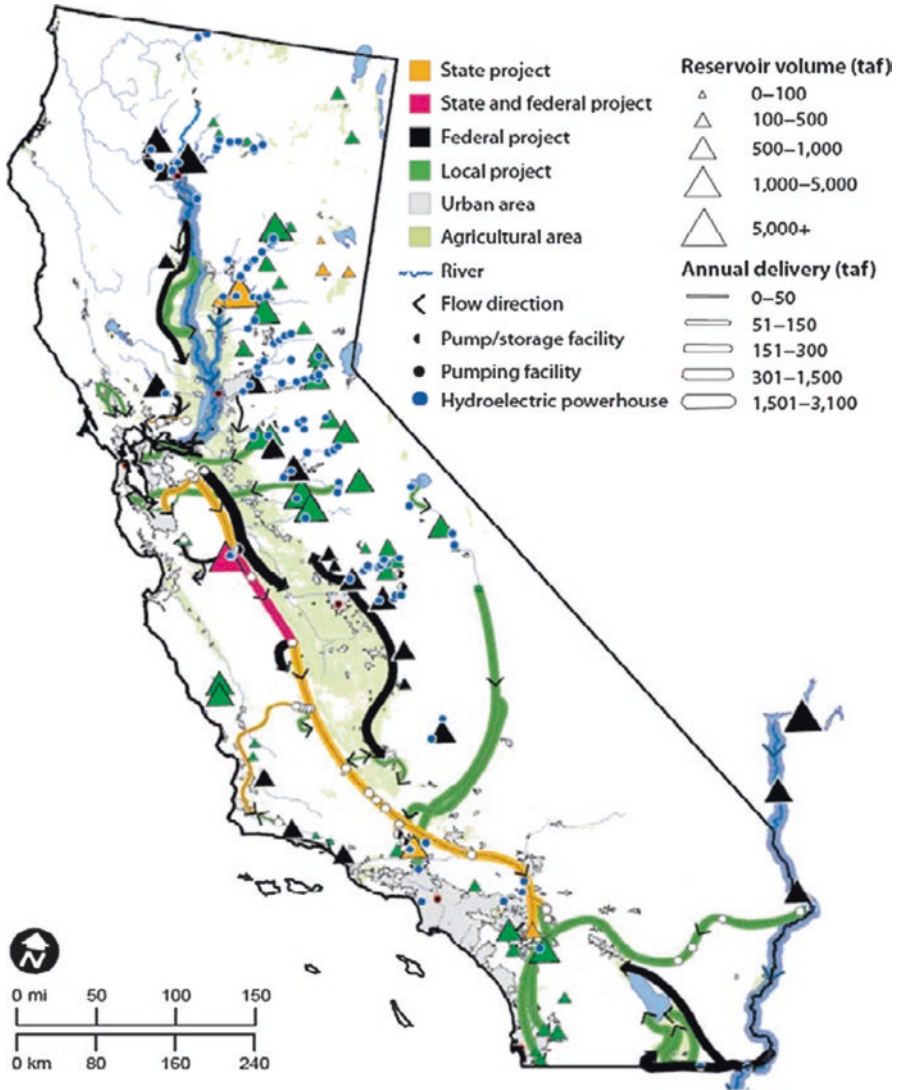


Fig. 26.1 California's surface water infrastructure and major landuse regions. "Project" refers to surface water reservoirs and associated canals. From: Hanak and Stryjewski (2012), [http://www.ppic.org/content/pubs/report/R\\_1112EHR.pdf](http://www.ppic.org/content/pubs/report/R_1112EHR.pdf), accessed 18 December 2018

center and southern parts of the state (Fig. 26.1). Since the 1930s, this infrastructure has been supplemented by large wells equipped with turbine pumps that tap into the alluvial aquifers underlying California's urban areas and irrigated agricultural lands. Groundwater accounts for one-third (in dry years over one-half) of California's water use (CDWR, 2014). Partially depleted aquifers represent the state's largest

potential storage capacity (Brush, Dogrul, & Kadir, 2013). Aquifers also function as a ubiquitous, natural local water treatment and delivery system.

Conflicts between urban, agricultural, and environmental water uses have always played an important role in California's economic and political development given the limited renewable water supplies (e.g., Reisner, 1993). While early water use focused on streams, competing uses of groundwater resources led to litigation and court trials already by the late 1800s. By 1904, the fundamental legal doctrine guiding California's groundwater resource management was well-defined.<sup>2</sup> The rapid expansion of groundwater use in the early and mid-1900s expanded the scope of groundwater conflicts, leading to far-reaching court decisions and the construction of massive surface water projects to address groundwater overdraft in California's coastal urban centers and its irrigated agricultural regions in the 1940s–1960s. Comprehensive statutory control of groundwater resources, while being considered for over a century, would not be realized until 2014. In the meantime, economic growth and increasing environmental awareness about in-stream flows continued to increase water demands beyond the capacity of existing surface water infrastructure and aquifer recharge, depleting groundwater supplies.

This chapter explores the history of and current developments in California's approaches to managing groundwater resources. An overview of the historical development of California's groundwater rights framework (Sect. 26.2) sets the background for exploring the development of groundwater management policy in the state (Sect. 26.3), which culminated in the enactment of the Sustainable Groundwater Management Act of 2014 (SGMA, Sect. 26.4). Subsequent sections explore stakeholder engagement (Sect. 26.5), technical-scientific assessment (Sect. 26.6), and infrastructure (Sect. 26.7) practices envisioned under the new legislation. Enforcement as the key driver for successful implementation of sustainable groundwater management is also briefly explored (Sect. 26.8). Finally, the chapter concludes (Sect. 26.9) by discussing key challenges facing local groundwater management agencies, as their work is not only subject to the provisions of SGMA, but also to overlapping and potentially competing and less well-defined legal doctrines and federal and state laws pertaining to the management of surface water resources, ecosystems, and water quality.

## 26.2 California's Water Rights Framework

In the United States, individual states rather than the federal government control water property and water use rights, except on federally owned lands (national parks, national forests, native American lands, etc.). California achieved statehood only in 1850, shortly after the beginning of the 1848 gold rush. Absent a long-standing body of state or federal law, California's people elected to use English

---

<sup>2</sup> *Katz v. Walkinshaw*, 141 Cal. 116 (1903).

common law as the foundation for deciding on many legal matters including the use and sharing of water resources.

Part of Mexico until 1848, early California settlements had already established community rights to surface water for irrigation, domestic, and other needs that were formally recognized by Congress as “pueblo water rights” when California became a state.<sup>3</sup> Lands under federal administration (45% of California’s land area) hold “federal reserved rights” to surface water<sup>4</sup> and to groundwater<sup>5</sup> to meet the water needs of these federal lands.

Early on, the state adopted common law riparian rights, which assigns a right to use water on lands adjacent to a stream. The water right only extends to the natural flows in the stream, not to additional flows that may be released, e.g., by upstream reservoirs. The right also does not permit storage of water for more than 60 days. Riparian water rights do not expire due to non-use. Shortages in natural stream flows are shared among users proportional to their water right.

Given the semi-arid nature of the state, most urban, industrial, and agricultural development in need of water occurred in areas not adjacent to streams. For those water users, the state adopted the principle of prior appropriation, commonly applied in other Western states with semi-arid and arid climates: water rights for non-riparian water users would be defined by the date of first diversion, the point of diversion, the diversion amount, and the use and place of use of the water. This may include storage for later use. Within the appropriative system, shortages are not shared among users. Instead, seniority decides who will have either full access or no access to their water right in case of water shortages (“first in time, first in right”). Non-use for more than 5 years terminates an appropriative water right, whereas riparian rights do not expire due to non-use. Pueblo water rights and federal reserved water rights are senior to most appropriative water rights.

Until 1914, water rights were declared by individual notification. In 1914, the state established statutory control over surface water rights. Since then, water rights applications have formally been submitted to and decided by the State Water Board (and its predecessor agencies). For groundwater, the state did not assume similar statutory control although the possibility was strongly considered in the development of the Water Commission Act of 1914 (Sax, 2002). Hence, groundwater users have not been regulated and do not need to apply for a water use permits. The only permit required for a new well is a county-issued well construction (drilling) permit.

Absent statutory control and explicit state policy, water conflicts over groundwater use have historically been deferred to and decided by the courts. Court decisions in turn were subject to interpretation of established legal doctrine and case law. Groundwater rights work somewhat analogous to surface water: under California’s

---

<sup>3</sup> *City of Los Angeles v. City of San Fernando et al.*, No. 650079, Superior Court of the State of California for the County of Los Angeles, 26 January 1979.

<sup>4</sup> *Winters v. United States*, 207 U.S. 564 (1908); *Arizona v. California*, 373 U.S. 546 (1963); *U.S. v. New Mexico*, 438 U.S. 696 (1978).

<sup>5</sup> *Cappaert v. United States*, 426 U.S. 128 (1976); *Agua Caliente v. Coachella Valley Water Dist.*, 849 F. 3d 1262 (2017).

correlative rights doctrine, landowners overlying an aquifer system have a right to use groundwater on their land. Similar to riparian rights, these overlying rights cannot be extinguished by non-use, i.e., they may exist as dormant water rights. Among overlying landowners (agricultural, private, and industrial water users), the water right is shared in relation to use by others, to the characteristics of the land parcel, and to the characteristics of the aquifer<sup>6</sup> (hence, “correlative” right). Groundwater that is not claimed by overlying landowners can be claimed by other pumpers under the prior appropriation doctrine. The most important appropriators in many groundwater basins are public water agencies (cities, water districts, etc.) that serve overlying landowners or export water to neighboring basins. Their right is generally considered junior to overlying, correlative rights.

Some groundwater rights can be obtained by “mutual prescription”, that is, by use of water that is “actual, open and notorious, hostile and adverse to the original owner” for at least 5 years.<sup>7</sup> Prescriptive water rights have become an important element to protect some water rights of cities and public water agencies overlying a groundwater basin against the (more senior) overlying rights of industrial and agricultural landowners and against dormant overlying rights.

Groundwater rights – like surface water rights – are a right to the use of water (“usufruct”) rather than outright ownership, which remains with the people of the state (Matthews, 2003). California’s constitution<sup>8</sup> dictates that water can only be pumped or diverted for reasonable and beneficial uses, a central element to all water rights decisions. Furthermore, the total amount of water pumped must not exceed the safe yield of a groundwater basin. In other words, groundwater rights do not extend to all groundwater physically present in a groundwater basin, only to the renewable amount of groundwater. In California, courts have never recognized a right to outright mining of groundwater.

Historically, groundwater conflicts among users over each party’s volumetric water right have occurred mostly in Southern California’s comparatively smaller (and more arid) groundwater basins. These are most susceptible to overdraft and – along coastal groundwater basins – suffer from seawater intrusion. The need to involve the courts for remedy meant the pursuit of costly lawsuits. Such efforts would most likely be extended only where overlying and appropriative users include influential and economically powerful parties – cities, industrial landowners, and large agricultural landowners and their associations. There, adjudications – court decreed allocations of groundwater rights among multiple users – have been performed, now including all or parts of 27 groundwater basins (Blomquist, 1992; Langridge, Brown, Rudestam, & Conrad, 2016a; Ostrom, 1990).

Adjudications have been initiated for widely differing reasons, may have involved few or many parties, and have led to a diversity of water management arrangements

---

<sup>6</sup> *Katz v. Walkinshaw*, 141 Cal. 116 (1903).

<sup>7</sup> *City of Pasadena v. City of Alhambra*, 33 Cal.2d 908 (1949).

<sup>8</sup> California Constitution Article 10 Section 2, enacted in 1928.



(Langridge et al., 2016a). Adjudications typically involve consideration of existing water rights (pueblo rights, federally reserved rights, overlying rights, appropriative rights, prescriptive rights, etc.), historic water use by individuals or groups of water users, groundwater basin conditions and safe yield, and, in few cases, seawater intrusion or other water quality issues. Adjudications have sometimes employed a “physical solution”, settling on a negotiated allocation of groundwater rights that seeks a pragmatic balance between historic water use and various, sometimes conflicting water rights, including dormant rights under California’ constitutional directive “that the water resources of the State be put to beneficial use to the fullest extent of which they are capable”.<sup>9</sup> The court appoints a Watermaster to execute and oversee the adjudication. The Watermaster is most often a local entity representing basin water interests, although small pumpers and disadvantaged communities are rarely participating in the adjudication or subsequent Watermaster activities (Langridge et al., 2016a). The Watermaster is in charge of monitoring and annual reporting, but may also engage in other water management activities – facilitating an increase in water supplies, additional groundwater storage, and water trading, or overseeing the reduction in groundwater pumping. Watermaster activities, if any, vary widely between adjudications as does the outcome with respect to addressing overdraft conditions (Langridge et al., 2016a).

A steady, central historical tenet of court decisions throughout the past century, including many of the adjudications, has been that groundwater rights are separate from and unrelated to surface water rights, despite their obvious hydrologic connectivity. This has left surface water right holders and environmental interests largely without legal tools to address negative impacts of groundwater pumping on stream flow and groundwater-dependent ecosystems. A recent case involving the public trust doctrine, a legal concept going back to Roman law, may change that. First employed in a 1980s court decision, it allowed the state to limit diversions of surface water and modify existing surface water rights permits.<sup>9</sup> In a 2018 decision, courts have – for the first time – affirmed the application of the public trust doctrine to groundwater pumping.<sup>10</sup> The public trust doctrine protects flows in navigable waters to the extent feasible and reasonable. Importantly, it may override existing water rights to tributary streams of navigable waters and to groundwater pumping that harms flow in navigable streams.

---

<sup>9</sup> *National Audobon Society vs. Superior Court*, 33 Cal. 3d 419 (1983); Bay-Delta Plan Update: Lower San Joaquin River and Southern Delta [https://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/bay\\_delta\\_plan/water\\_quality\\_control\\_planning/](https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/), accessed 18 December 2018.

<sup>10</sup> *Environmental Law Foundation v. State Water Board*, 3rd District Court of Appeals, No. C083239, August 29, 2018.

## 26.3 History of California's Groundwater Management Policy

California has a diverse and expansive institutional landscape that includes hundreds of irrigation and water related special acts districts (LAO, 2002) – quasi-governmental institutions with elected boards, taxing powers, and powers of eminent domain. First authorized by the state through the Wright Act of 1887, these subdivisions of the State government manage and distribute surface water among their landowners (including cities and communities). In contrast, groundwater is typically developed and used by landowners directly, not subject to scheduling requirements and shortages. Only 15 special acts districts have some groundwater management related authority, with large urban districts (Orange County Water District, Santa Clara Valley Water District) having been among the most active, since about the middle of the twentieth century (Langridge, Sepaniak, & Conrad, 2016b). Special acts districts with groundwater management responsibilities are mostly focused on water supply augmentation to address potential groundwater overdraft and, along the coast, looming seawater intrusion. They employ financial incentives, replenishments fees, and conservation measures to control groundwater extraction, where needed.

Groundwater management has been part of California's political discussion since the early twentieth century. As early as 1912, legislative proposals existed to address groundwater extraction. But already at that time agricultural interests appear to have been most influential in nudging the legislature against taking statutory control over groundwater as part of the controversial 1914 water rights reform (Sax, 2002, p. 296). Subsequently, groundwater management was most actively pursued in urbanizing areas of southern California and the San Francisco Bay Area. There, groundwater resources quickly became overdrafted, land subsidence threatened and damaged infrastructure, most prominently the surface water canal infrastructure, and seawater intrusion forced water supply wells of large cities to be closed (Hanak et al., 2011; Lipson, 1979; Schneider, 1977). Adjudication of groundwater rights led to Watermaster appointments that variously oversaw groundwater extraction.

Early to mid-twentieth century court-decreed limitations to groundwater extractions reinforced the period's efforts to build out surface water infrastructure in California, transferring surface water from the north and from surrounding mountains to Central and Southern California's urban and agricultural basins. Already by the middle of the twentieth century, the concept of "conjunctive use" of groundwater and surface water began to take hold.<sup>11</sup> Urban water districts took advantage of storage capacity in groundwater basins for seasonal or long-term transfer of surplus surface water; or to trade groundwater (that would otherwise be pumped) for surface water deliveries in exchange for title to the unpumped groundwater volume ('in lieu recharge'). Courts confirmed the security of surface water stored underground

---

<sup>11</sup> *Los Angeles v. Glendale*, 23 Cal.2d 6 (1943).



against claim by nearby groundwater pumpers, within the correlative rights of overlying owners.<sup>12</sup> Very few, mostly urban special acts district (e.g., Orange County Water District) used their tax authority to levy extraction fees from landowners (including cities) within the district boundaries that would pay for the replenishment of the aquifer through a portfolio of water management measures (Blomquist, 1992; Langridge et al, 2016b).

Groundwater replenishment would take numerous forms through the second half of the twentieth century: A major approach in the 1950s through 1970s was to recover lowering water tables through less groundwater pumping that was made possible by developing additional surface water supplies, locally, regionally, or from across the state (Colorado River Project, Central Valley Project, State Water Project). Groundwater recharge basins were built to supply aquifers with additional recharge that would balance extraction by groundwater pumpers. In some agricultural regions, irrigation districts actively or inadvertently replenished groundwater during the wet winter and the spring runoff season, by filling unlined canals or by using landscape depressions as natural flooding basins (e.g., Consolidated Irrigation District, 2009).

By the 1980s, environmental concerns and nearly full build-out of the surface water infrastructure stopped the expansion of water supplies. Importantly, new environmental legislation (the Endangered Species Act 1973 (ESA)<sup>13</sup> and the Clean Water Act 1972 (CWA)<sup>14</sup> and court decisions (the Public Trust doctrine<sup>15</sup>) began to limit or reduce the amount of surface water being diverted or transferred through California's water grid.

Constraints on surface water development critically widened groundwater management portfolios over the recent three decades, adding some creative solutions (Nelson, 2011): urban areas engaging in local stormwater capture for groundwater recharge; urban-agricultural exchanges of treated wastewater for use in irrigation and in turn traded for agricultural groundwater that remained unpumped for groundwater protection; treatment of poorer quality native groundwater; groundwater replenishment with highly treated urban wastewater; use of aquifer storage and recovery (ASR) schemes (Dahlke et al., 2018b); development of water markets (Hanak & Stryjewski, 2012); and some water conservation measures that culminated in a statewide voluntary urban conservation cutback of 25% during the 2012–2016 drought (Palazzo et al., 2017). Large groundwater banks were being developed beginning in the 1980s, holding over 2 km<sup>3</sup> of water for long-term storage and tied into the statewide water transfer grid (Hanak & Stryjewski, 2012).

Despite these efforts and significant success in restoring groundwater storage in some of the most severely affected urban regions of southern California and the San Francisco Bay Area, groundwater overdraft remained an issue, particularly in

---

<sup>12</sup> Alameda County Water District vs. Niles Sand and Gravel Co., 37 Cal. App. 3d 924 (1974).

<sup>13</sup> 16 U.S.C. § 1531 et seq.

<sup>14</sup> 33 U.S.C. §1251 et seq.

<sup>15</sup> *National Audubon Society v. Superior Court*, 33 Cal.3d 419 (1983).

irrigated agricultural regions, the largest of which is California's Central Valley. The Central Valley encompasses about 30,000 km<sup>2</sup> of irrigated lands, representing 75% of California's irrigated agriculture (CDWR, 2014).

Concern over continued over-allocation of groundwater would be particularly palpable during California's frequent drought periods, inevitably leading to heated political discussions and triggering calls for action from constituents. Over the past half century, each major drought period would see gubernatorial or legislative actions attempting to address the largely unchecked groundwater overdraft (Cannon Leahy, 2016). The 1959–1962 drought yielded legislation that funded extensive groundwater investigations to assess the state's groundwater resources. An Interim Committee on Water, in 1962, concluded with a sobering assessment of groundwater conditions. Almost 20 years later, following a record dry year in 1977–1978, then-governor Jerry Brown called for a Water Rights Commission to review water rights and groundwater management in California. The Commission recommended that the state take statutory control of groundwater management and outlined a governance structure that emphasised local control under state oversight.

Wet years followed, and the legislature had little appetite for creating the proposed legislation. However unlike the 1950s, 1960s, and 1970s, the next 40 years would bring drought conditions to California at an accelerating pace, intensifying discussions over state control of groundwater. Following the 1988–1992 drought, the legislature passed Assembly Bill (AB) 3030, providing a wide range of local agencies the authority to develop local groundwater management plans<sup>16</sup>. The legislation provided neither binding requirements to do so nor specific guidance on the implementation of local groundwater management. The latter shortcoming was addressed 10 years later, during another drought. In 2002, Senate Bill (SB) 1938<sup>17</sup> was enacted to provide a stiff financial incentive to local water agencies for developing groundwater management plans (GMPs): state support for water projects would not only be contingent on local agencies having in place a GMP, but significant minimum requirements for the content of such GMPs were put in place. Still, there was no requirement to go beyond "planning a plan". The 2007–2009 drought added to the discussion of groundwater reform law, but yielded little beyond additional legislatively required water level monitoring<sup>18</sup> to supplement already existing, long-term groundwater level monitoring programs.

Water, irrigation, and special acts districts throughout California, representing both urban and agricultural water users, would continue to be the key lobby against additional regulations and bureaucracy for groundwater use, which remained the by far least expensive and simplest water resource to tap into and manage at the discretion of individual landowners and local authorities, without state oversight.

---

<sup>16</sup> California Water Code §10750–10755

<sup>17</sup> Senate Bill 1938, 2002, [https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill\\_id=200120020SB1938](https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200120020SB1938), accessed 18 December 2018

<sup>18</sup> Senate Bill X7-6, 2009, [http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb\\_0001-0050/sbx7\\_6\\_bill\\_20091106\\_chaptered.html](http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0001-0050/sbx7_6_bill_20091106_chaptered.html), accessed 18 December 2018

With groundwater conditions becoming increasingly critical in the early 2000s, and with many urban districts advancing extensive groundwater management efforts, agricultural districts not only found themselves more and more isolated in resisting groundwater reform, but voices grew louder from within the agricultural community to more seriously begin to address groundwater management in the irrigated regions of California. In 2009, a third drought year in succession, the Association of California Water Agencies, the state's largest affiliation of water agencies representing both urban and agricultural water agencies and their water user members, developed a set of policy principles on groundwater management.<sup>19</sup> The policy principles supported strong local groundwater management, integrated with surface water management, and demanded significantly more accountability and transparency than currently practiced, while rejecting outright state control.

Only 3 years later, the State was facing yet another drought, one that would last 5 years, from 2012 to 2016. Already by 2013, Governor Jerry Brown, re-elected in 2011 and having initiated the earlier Water Rights Commission during his 1975–1983 term, made a public call for new legislation to be developed. Two major proposals emerged by spring of 2014 including proposed legislation from the Association of California Water Agencies. By fall of 2014, the legislature passed and the governor signed the Sustainable Groundwater Management Act (SGMA),<sup>20</sup> setting in motion the largest water management reform in California history since the 1914 Water Commission Act and the 1969 Porter Cologne Water Quality Control Act. SGMA represents the first comprehensive statutory law governing the management of groundwater in California.

## 26.4 Principles of Sustainable Groundwater Management in California

The principles of the Sustainable Groundwater Management Act follow in the footsteps of the Water Rights Commission's 1978 final report recommendation: that groundwater be managed locally by local agencies; and that "groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses".<sup>21</sup> These are the two founding pillars for twenty-first century California groundwater management. Importantly, and with substantial foresight and experience, SGMA provides an extensive and detailed definition of sustainability that establishes unequivocal

<sup>19</sup> [https://www.acwa.com/wp-content/uploads/2017/03/groundwatermanage\\_policy\\_3.pdf](https://www.acwa.com/wp-content/uploads/2017/03/groundwatermanage_policy_3.pdf), accessed 18 December 2018.

<sup>20</sup> [http://opr.ca.gov/docs/2014\\_Sustainable\\_Groundwater\\_Management\\_Legislation\\_092914.pdf](http://opr.ca.gov/docs/2014_Sustainable_Groundwater_Management_Legislation_092914.pdf), accessed 18 December 2018.

<sup>21</sup> California Water Code §113.

frontiers in future California groundwater management. Sustainability is defined as the absence of six specific “undesirable results” which are defined as:<sup>22</sup>

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The significance of these definitions and principles cannot be overstated. In 2014, about 2 months prior to the passage of SGMA, but at a time when much of the statute had been developed and undergone broad discussion, Paul Wenger, then-president of the California Farm Bureau Federation, wrote an opinion article headlined “Groundwater legislation could be checkmate”.<sup>23</sup> While perhaps meant to draw attention to a perceived looming defeat for agriculture, the analogy was, perhaps inadvertently, but also implicitly rather foresightful: all the pieces on the chess board would finally be in complete and full relation to each other. For the first time, California’s statutes would recognize the physical linkage between groundwater and surface water, between groundwater and ecosystems, between water supply and water quality, and between water use and land use. Importantly, the legislation also mandated that sustainable management of groundwater be substantively considerate of these linkages.

It is too early to begin to assess the full impact of the broad, integrated water management perspective that SGMA takes on sustainability. Local stakeholders will need to balance conflicting interests of groundwater users, surface water users, environmental interests, environmental justice concerns, land use planners, and others. But already, SGMA is beginning to become a catalyst for more holistic, integrated thinking in water and land management in regions that have historically been reluctant to engage in groundwater management. While SGMA and the focus on achieving groundwater sustainability may temporarily be distracting from nearly 20 years of statewide efforts in integrated regional water management planning

---

<sup>22</sup> California Water Code §10721(x)

<sup>23</sup> <http://agalert.com/story/?id=6829>, accessed 18 December 2018

(IRWMP<sup>24</sup>), SGMA may become a critical catalyst to bring IRWMPs to full maturity, across all of California's important groundwater basins.

The SGMA legislation<sup>25</sup> required the establishment of local groundwater sustainability agencies (GSAs) by 2017 and the development of groundwater sustainability plans (GSPs) – by 2020 for critically overdrafted basins and by 2022 for all other basins. GSPs must be designed to achieve sustainable groundwater conditions within 20 years of the initial GSP completion (2040 or 2042, respectively). The state has substantial oversight of the local process with requirements for regular, 5 year review of GSPs and their implementation. Failure to form a local GSA, to develop a GSP, or to implement a GSP leads to mandated state take-over of local government in managing groundwater, at cost to affected groundwater users.

The legislation designated two existing state agencies with the oversight and implementation of new regulations: The Department of Water Resources (DWR, within the California Natural Resources Agency), primarily a state planning and technical support agency (but also the operator of the State Water Project), was designated to develop the detailed regulations within 2 years of passing of the act, to provide technical guidance and assistance, and also to administer state financial support for local GSAs. DWR will be the agency in charge of reviewing GSAs and GSPs on a regular 5-year basis. DWR is the agency that determines compliance with SGMA. In case of non-compliance, DWR turns matters over to the State Water Resources Control Board (within the California Environmental Protection Agency), an enforcement agency currently overseeing surface water rights, water quality (through its nine regional member agencies, the Regional Water Boards), and implementation of drinking water regulations.

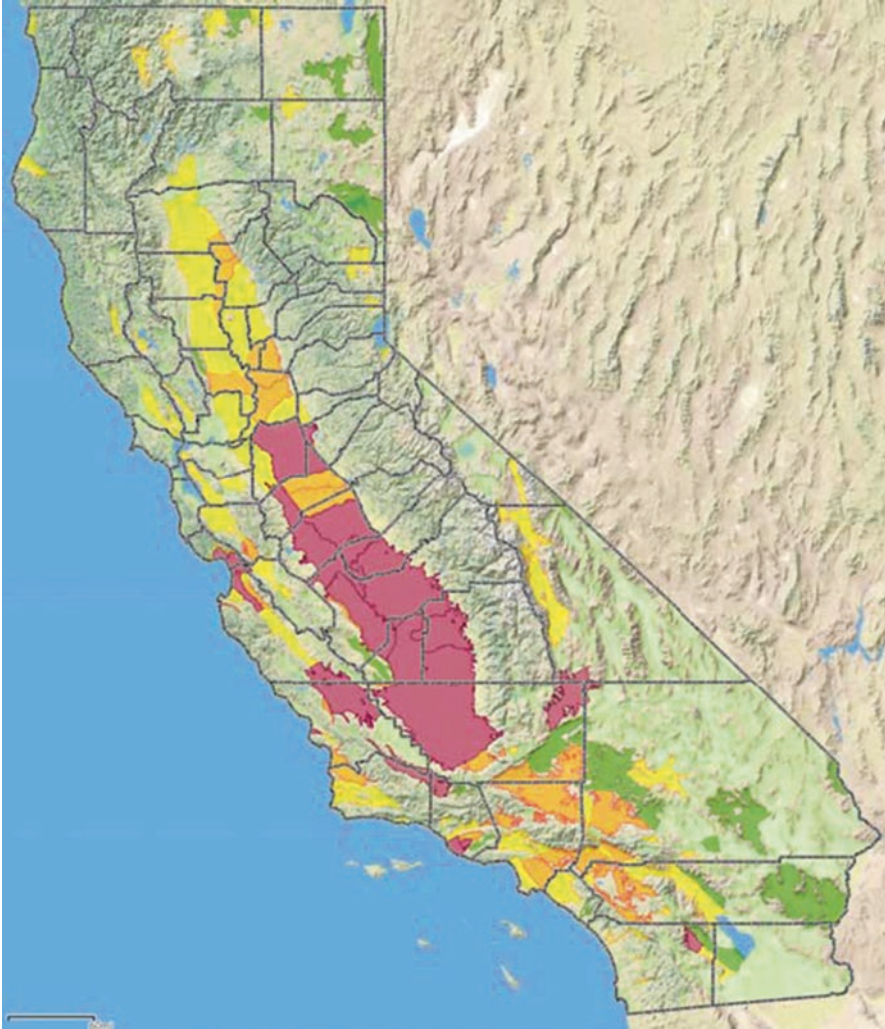
While SGMA applies to all California groundwater and to addressing all past, ongoing, and future undesirable results, regulatory and therefore most practical implementation is limited both, in space and in time: Spatially, SGMA requires GSA formation and GSP development and implementation only in areas overlying medium and high priority groundwater basins, but not in low and very-low priority groundwater basins. Priority is set by the state (DWR) based on technical-scientific criteria related to groundwater use, population density, water use, and existing groundwater conditions. The prioritization criteria and basin status will be reviewed by DWR every 5 years. California is divided into 515 groundwater basins (Fig. 26.2). Some of these basins are delineated using hydrologic boundaries, many are delineated by a combination of hydrologic and political boundaries, particularly in the Central Valley and other large hydrologic groundwater basins. Only alluvial (unconsolidated sedimentary) groundwater basins are currently designated as groundwater basins. DWR has instituted a basin boundary adjustment process that will occur every few years, as needed or requested by local agencies. California also has some smaller volcanic aquifer systems. Historically, DWR has not designated those as

---

<sup>24</sup> Senate Bill 1672, 2002, [http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb\\_1651-1700/sb\\_1672\\_bill\\_20020921\\_chaptered.html](http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb_1651-1700/sb_1672_bill_20020921_chaptered.html), accessed 18 December 2018.

<sup>25</sup> <http://groundwater.ucdavis.edu/sgma/>, accessed 18 December 2018.





**Fig. 26.2** California's 515 groundwater basin: very low and low priority (light and dark green), medium priority (yellow), high priority (orange), critically overdrafted high priority (burgundy). Status: 2017. From: <https://gis.water.ca.gov/app/boundaries/>, accessed 15 September 2018)

groundwater basins, but has recently accepted the first volcanic aquifer basin boundary adjustment and may add more in the future. Over 120 of the 515 groundwater basins are currently classified as medium- and high priority basins with 21 basins classified as “critically overdrafted” (Fig. 26.2). These medium and high priority basins encompass over 95% of current groundwater usage.

Temporally – with respect to the “age” of undesirable results – SGMA limits requirements for addressing undesirable results to those undesirable results that occurred on or after January 1, 2015. In other words, undesirable results such as



water level decline, seawater intrusion, land subsidence, or groundwater capture of surface water must be addressed by a GSP only if they began to occur or to the degree that they degraded after 2014. Undesirable results that already existed at the time the legislation was enacted may be addressed by a GSA, but the GSA is not required to do so. In other words, further decline in water table, additional land subsidence, the advancement of a seawater intrusion front, or additional depletion of streams must be avoided. But an already existing low water table need not be reversed to higher levels that existed perhaps decades ago, except to control seawater intrusion. By focusing the regulatory efforts on those basins with the highest usage and on continued expansion of undesirable results rather than recovery of historic conditions, the legislation cast a practicable management framework that would also have broad support from constituents.

Local agencies that were given eligibility to form a GSA include cities, counties, irrigation, water, and other special acts districts, resources conservation districts, flood control districts, and others. By 2017 – within 3 years of the legislation – over 300 new agencies had formed, overlying the over 120 medium- and high priority groundwater basins. Agency formation required a minimum amount of notification and public hearing. Where multiple agencies provided notification to become a GSA, agencies needed to work out among themselves how to proceed before finalizing the GSA(s). The path to creating this many GSAs in such a short period of time was a perhaps unique experience in administrative practice. The process diverged widely between GSAs, some based on broad engagement of stakeholders and the public, others with only minimal public participation. SGMA does not prescribe the governance structure of GSAs.

The resulting GSAs are equally diverse. Some are single agencies partially or fully overlying a groundwater basin. Some single agency GSAs may even overly multiple groundwater basins (e.g., a county agency with multiple subbasins within its boundaries). Some GSAs are contractual arrangements (through a memorandum of understanding or through a joint powers agreement) among multiple local agencies with agreed-upon governance structures and representation. Some of these GSAs will write a single GSP, some will write multiple GSPs (if overlying multiple basins), some GSAs will collaborate with other GSAs to write a GSP that applies across multiple GSAs. Analogously, some GSPs will cover only a part of a groundwater basin, some GSPs will extend over the entire groundwater basins, some GSPs may partially or fully overlap with multiple groundwater basins. The legislation requires very close coordination if multiple GSPs are written within a single designated groundwater basin. Some coordination is also required by law between GSPs in adjacent groundwater basins.

The development and content of groundwater sustainability plans was the subject of detailed regulations developed by the Department of Water Resources. The department sought substantial input from stakeholders, regulated entities, and technical experts during the drafting of the regulations in 2015 and 2016. The regulations set up the requirements for GSP elements and reflect on the criteria by which the GSPs will be evaluated in DWR's initial and five-yearly reviews.

- Groundwater Sustainability Plans cover three broad areas:
- governance, process, stakeholder engagement, learning, and communication;
- technical and scientific assessment, monitoring, modeling, data management and reporting; and
- project development and implementation to reduce groundwater demand or enhance groundwater supplies.

These areas are discussed in more detail in the following sections.<sup>26</sup>

## **26.5 People: Communication and Engagement in the GSP Process**

Water users and other stakeholders in California's groundwater basins are diverse and include farmers (agricultural landowners), cities and communities, environmental interests and NGOs, environmental justice representatives, representatives of domestic well users, land use zoning agencies, water agencies, representatives of minority communities, economically disadvantaged communities, and Native American tribes. Water users and stakeholders are given participatory roles in the GSP process. GSAs are required to provide public notification and opportunities for public participation in the GSP development. The governance of the GSA may reflect some of that diversity; many GSAs have advisory committees that meet regularly to assure a broader participatory approach across all stakeholder groups.

An emerging challenge is capacity: With over 300 GSAs, some user and stakeholder groups find themselves limited in their (personnel or people) capacity to attend the numerous meetings. Particularly public members of advisory committees and those representing smaller NGOs have found themselves stretched thin by the large number of meetings in areas with many GSAs. Some participation is also limited by the ability to provide funding toward the cost of operating a GSA, providing travel cost, or finding in-kind volunteer contributions.

## **26.6 Creating the Knowledge Base: GSP Monitoring, Assessing, Reporting**

A thorough understanding of the groundwater system within the governance area and – more broadly – within the groundwater basin (where GSAs share governance of a basin) is a critical basis for sustainable management. Education and information of stakeholders, assessment of the groundwater sustainability status, and evalu-

---

<sup>26</sup>Further supporting information on SGMA and its implementation is available at <http://groundwater.ucdavis.edu/sgma>, accessed 18 December 2018

ation of any actions needed is based on sufficiently detailed groundwater characterization. All GSPs are therefore required to include the following elements<sup>27</sup>:

- development of a hydrogeologic conceptual model
- description of groundwater conditions with respect to potential undesirable results
- development of a water budget
- development of sustainable management framework with goals, desired outcomes, and thresholds for actions
- development of a monitoring network
- descriptions of project and management actions
- reporting and data management

For each element, the state laid out broad minimum requirements in the regulations, but those will leave significant flexibility to individual GSAs as they are developing their GSPs. DWR has also developed non-binding best management practices and guidelines<sup>28</sup> that are intended to provide some basic technical education and guidance, but also to articulate DWR's expectations when reviewing GSPs.

While details in the GSP development are anticipated to vary widely, DWR personnel will likely be engaged in the local process as observer and in an advisory role to ensure that there is ongoing feedback between the regulator and the GSA. The longer-term process is designed to encourage adaptive management, whereby new information will update the conceptual models, water budgets, numerical models where used, and inform decisions on projects and actions, and planning of additional monitoring. GSPs will need to be updated by GSAs every 5 years for formal review by DWR.

The six undesirable results will play a central role in the development of the GSP. The regulations have coined “sustainability indicator” as an operational term for speaking and articulating the linkage between undesirable results, monitoring systems, management goals, and thresholds (Fig. 26.3). Sustainability indicator



**Fig. 26.3** The six sustainability indicators to be considered in the GSPs (CDWR, 2017)

<sup>27</sup>California Code of Regulations Title 23(Div.2) §350 -§358, 2016, [https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP\\_Emergency\\_Regulations.pdf](https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf), accessed 18 December 2018.

<sup>28</sup><https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents>, accessed 18 December 2018.

refers to “any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results”.<sup>29</sup>

Each sustainability indicator – if at all relevant to the basin – requires a monitoring system that can provide metrics on the status of the sustainability indicator. Monitoring systems need not be separate between the sustainability indicators. The overall sustainability goal, identified by the GSA, must be translated into “measurable objectives” and “minimum thresholds” for each sustainability indicator. Measurable objectives are defined in SGMA and represent the range of values in the sustainability indicator metrics that reflect a desirable, perhaps optimal sustainability indicator status, e.g., an acceptable range of desirable water levels, groundwater storage, or concentrations in water quality indicators. Minimum thresholds, conceptually defined in SGMA, operationally are values beyond which the status of the sustainability indicator becomes undesirable. The minimum threshold is a numeric value within the same metric (measurement or aggregated measurement obtained from the monitoring system) used for measurable objectives.

With few exceptions explicitly contained in SGMA, the state provides some guidance, but does not prescribe what these metrics should be or what values they must take on – this will be left to the GSA to decide. However, in the state’s review of the GSP, the state has a duty to evaluate whether measurable objectives and minimum thresholds are defined appropriately, especially when compared to those defined by other GSAs that share the same groundwater basin or are located in adjacent groundwater (sub-)basins.

Equipped with a hydrogeologic conceptual model, the water budget – perhaps from a groundwater model, and knowledge of the relevant sustainability indicators, GSA managers and stakeholders decide on monitoring networks needed, set measurable objectives and minimum thresholds, and possibly develop trigger thresholds for actions and projects.

## **26.7 Aligning Water Use with Abstraction Limits: GSP Projects**

Actions and projects will need to be identified in the GSP to demonstrate to the state that the GSA has the capacity to address undesirable results when they occur. GSAs will initially focus on increasing groundwater availability through additional groundwater recharge before turning to the politically more painful, challenging task of reducing groundwater demand. Funding for GSA activities will partly be provided through (competitive) grants offered by the state, but a significant portion will come from taxes and fees locally generated by the GSAs, which have been given authority through SGMA to raise such fees and taxes.

---

<sup>29</sup>California Code of Regulations Title 23 (Div. 2) §351(ah)

Many areas have a long history of groundwater enhancement projects, through managed aquifer recharge of local stormwater runoff, wastewater recycling, and others as outlined above. However, some agricultural regions are losing historic groundwater recharge from surplus irrigation, as farmers adopt more efficient irrigation practices to address water shortages and to control pollutants (especially nitrate) leaching to groundwater.

Recently, high flood flows, typically uncaptured, have been identified as an additional source of water (Kocis & Dahlke, 2017). Managing these high flow requires additional storage, not currently available. A new form of groundwater enhancement is emerging in form of agricultural managed aquifer recharge during the winter (“Ag-MAR”, Harter & Dahlke, 2015; Niswonger, Morway, Triana, & Huntington, 2017). Ag-MAR would take advantage of the existing agricultural landscape, at a large scale and using existing infrastructure, during a period when crops are dormant and when the risk for leaching agricultural chemicals can be minimized. Ag-MAR would provide potentially multiple benefits. Besides enhancing groundwater storage, winter flooding and recharge in agricultural landscapes offers opportunities to improve groundwater quality, but also to enhance ecosystem services. Current pilot projects are implemented in permanent crops – almond orchards, grape vineyards, and alfalfa (Dahlke, Brown, Orloff, Putnam, & O’Geen, 2018a). To take full advantage of available stormwater flows, additional action needs have been identified, including re-operation of surface water reservoirs for conjunctive storage in groundwater and surface water, additional infrastructure investment for conveyance of stormwater runoff, agronomic research to investigate feasibility of off-season recharge in a variety of crops, and clarification of water rights (CDWR, 2018; Fogg & Bernacchi, 2018).

Controlling groundwater demands will be necessary where enhancement of groundwater recharge is insufficient to meet sustainability goals. In urban areas, water conservation has played an important role in adjusting to limited water resources. During the 2012–2016 drought, urban areas achieved a statewide conservation goal of 25% water use reduction (Palazzo et al., 2017).

Agricultural regions will bear the most significant economic impact where groundwater pumping restrictions need to be put in place. There, less groundwater pumping translates into immediate economic losses, as other sources of water are unavailable. In the San Joaquin Valley (the southern and central part of the Central Valley), annual groundwater overdraft is estimated to be on the order of 2 km<sup>3</sup> (Schneider, 1977). Additional surface water supplies that may be developed for increasing groundwater recharge (including in lieu recharge) are limited by the ability of farms to pay. Current estimates suggest that additional surface and groundwater projects in this region may address only about one-third of the overdraft (Hanak et al., 2019).

The remaining overdraft will need to be achieved by fallowing at least 200,000 ha or more of currently irrigated agricultural production, a reduction of 5–10% of the current irrigated agricultural footprint. Ways to lessen the impact of this landuse change are currently under discussion but have yet to yield substantial changes in governance or local planning decisions. Key elements being proposed include (Hanak et al., 2019):

- creation of water markets that provide growers flexibility to sell or buy groundwater across their region and would allow for water transfers from areas with larger water endowments to areas with limited or no ability to enhance groundwater recharge.
- integration of groundwater planning with landuse planning to develop economically viable alternative land uses that do not depend on groundwater or much less so (e.g. development of natural dry-land conservation areas, especially where markets or government payments are available for conversion to conservation habitat; development of solar photovoltaic parks or other low water-impact industries).
- integration of planning activities between local surface water, groundwater, water quality, and landuse planning agencies.

For the San Joaquin Valley, current estimates show economic impacts to agriculture can be limited to about 5% of current production, with water markets and other measures in place (Hanak et al., 2019). Agricultural production within a reduced spatial footprint will likely increase the market share of high value crops, with low value crops disappearing. GSAs will need to each make their own choice in electing from this portfolio of options to achieve local groundwater pumping reductions.

## 26.8 Designing an Effective Enforcement System

Enforcement occurs at three levels: at the GSA-level, through DWR, and through SWB. GSAs are given statutory authority to ensure compliance by individual groundwater users and may impose civil penalties on individual parties that do not comply with a GSP. DWR was given the authority to develop GSP requirements and criteria and will review individual GSPs on a five-yearly schedule. GSPs not found in compliance will be designated “probationary”, which puts the management of the area into the hands of the State Water Board (SWB).

The SWB is not only the designated enforcement agency for SGMA, but already administers surface water rights and oversees groundwater quality regulations through its nine regional water boards. Hence, the agency – unlike DWR – will be able to draw from decades of experience in law enforcement on water matters. Perhaps most importantly, the success of SGMA hinges largely on the motivation of local stakeholders to implement painful and costly SGMA measures because they feel sufficiently threatened by the prospect of SWB taking over groundwater management, if local GSAs fail to form, fail to develop an appropriate GSP, or fail to implement a GSP properly.

The role of the SWB is defined in Chapter 11 “State Intervention” of SGMA.<sup>30</sup> Not inadvertently, “chapter 11” makes open and notorious reference to the colloquial term “filing for chapter 11”, that is, filing bankruptcy. The expression refers to

---

<sup>30</sup>California Water Code §10735 and §10736



Chapter 11, Title 11 of the United States Code, commonly known as the “Bankruptcy Code”, which allows for reorganization under U.S. bankruptcy laws. SGMA’s chapter 11 allows a local agency to remedy deficiencies within 6 months. Otherwise the SWB will be responsible for developing an interim plan that emphasises reduction of groundwater extraction over other groundwater management tools. Local control may be re-established under qualifying conditions at a later time.

Chapter 11 and the concept of state control of groundwater resources was designed to create strong motivation to local groundwater stakeholders and agencies to comply with SGMA regulations rather than leaving matters to a central state agency. In the short term, the state agency would likely be overwhelmed if a large number of basins had refused to form GSAs or failed to provide adequate GSPs. But for the intermediate and long-term, the economic, social, and local political cost of state control needed to be setup in ways that sends a clear signal to local agencies that local control and compliance would be preferable over control under chapter 11. To that end, SWB reacted to SGMA by immediately creating a SGMA enforcement unit with substantial funding to organize and prepare for enforcement actions. An early component of those developments was publication of a fee schedule that would be imposed on individual groundwater pumpers in areas managed under chapter 11. These fees would only cover the cost of state management. These costs are in addition to the pumpers’ financial responsibility for planning costs and implementation of projects and actions, costs that incur even under local management. But under local management, these costs can be partially recovered through state grants or funded through local markets (Hanak & Stryjewski, 2012).

## **26.9 SGMA and GSPs at the Intersection with Other Laws and Rights**

The framework outlined in SGMA extends well beyond the groundwater management efforts that California has historically engaged in, e.g., under adjudications or through special acts districts, and beyond efforts that will be the focus of critically overdrafted basins – addressing groundwater overdraft, land subsidence, and possibly seawater intrusion. SGMA requires groundwater management agencies to also consider the water quality implications of their activities (through the water quality sustainability indicator), and the connectivity between groundwater, surface water, and groundwater-dependent ecosystems (through the groundwater-surface water sustainability indicator). These mandates close the loop on many unintended consequences of groundwater pumping. But they represent largely unexplored frontiers in California and the Western U.S. water management landscape.

GSAs responsibility for groundwater quality and for pumping impacts on surface water and groundwater-dependent ecosystems overlap and interact substantially with other regulatory efforts and legal doctrines under federal and state law (Cantor, Owen, Harter, Green Nylen, & Kiparsky, 2018). This adds significant

uncertainty to the development of GSPs as science and new technical approaches will need to be developed to appropriately address these two sustainability indicators, while the relationship to other regulatory programs and potential legal liabilities remains without much state or legal guidance (Cantor et al., 2018).

The mandate for management of the groundwater-surface water interaction raises a number of questions that GSAs will need to consider, with little guidance from the state or the courts beyond basic requirements for quantifying the amount of historic and current depletion of surface water due to groundwater pumping. These questions include (Cantor et al., 2018):

- the interaction of surface water law with groundwater law
- the definition of “significant and unreasonable” adverse impacts to beneficial uses and users of surface water
- the allocation of responsibilities to various entities and parties in addressing groundwater – surface water interactions
- finding processes to effectively resolve conflicts among parties
- the deployment of a variety of monitoring and assessment tools to quantify the groundwater – surface water interactions at various spatial and temporal scales

Table 26.1 provides an overview of key legal doctrines, regulations, and laws that will need to be considered by GSAs – their boards, advisory committees, and stakeholders. Among those, several have significant potential to interfere or conflict with or supersede basic SGMA requirements:

- SGMA explicitly protects existing surface water and groundwater rights. However, the requirement to bring groundwater use into harmony with surface water use may directly conflict with existing surface water rights or with existing groundwater rights. A GSA will need to set an ambitious agenda to address these conflicts (Owen, Cantor, Green-Nylen, Harter, & Kiparsky, 2019).
- instream flow requirements, in addition to surface water rights, have been adjudicated by SWB on only a few streams. SWB is in the process of expanding instream flow rights, which may require curtailments by both surface water and groundwater users.<sup>31</sup> The distribution of these curtailments between existing surface water and groundwater rights holders is highly uncertain, providing both, opportunities and risks for GSAs to play an active, perhaps central role in facilitating a resolution to such conflicts.
- SGMA explicitly requires GSPs to comply with existing laws. The federal (and state version of the) ESA and CWA have proven to bear significant importance on the management of surface water to protect ecosystems and water quality

---

<sup>31</sup> [https://www.waterboards.ca.gov/waterrights/water\\_issues/programs/applications/instream\\_flow\\_dedication/](https://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/instream_flow_dedication/), accessed 18 December 2018; [https://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/bay\\_delta\\_plan/water\\_quality\\_control\\_planning/](https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/), accessed 18 December 2018; [https://www.waterboards.ca.gov/waterrights/water\\_issues/programs/bay\\_delta/docs/sed/sac\\_delta\\_framework\\_070618%20.pdf](https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/sed/sac_delta_framework_070618%20.pdf), accessed 18 December 2018

**Table 26.1** Summary of important laws, regulations, and legal doctrines that may affect and overlap with the development of the groundwater-surface water interaction sustainability indicator in a groundwater sustainability plan in California

Area of law or regulation	Key intersections between SGMA and other laws in the context of groundwater-surface water interactions
Reasonable Use Doctrine	Groundwater use, like all water use in California, is subject to the reasonable use doctrine. But the practical implications of the doctrine are not entirely clear. Reasonable use is, by nature, a flexible and highly context-dependent concept that is based in part on value judgments.
Water rights	SGMA explicitly does not alter surface water or groundwater rights. However, the implications of bringing a groundwater basin’s water budget into sustainable balance may bear directly on both. SGMA does not provide a formula for resolving conflicts between surface water and groundwater rights, but it does provide opportunity and a potential forum for doing so—if GSAs are ambitious.
Regulatory takings	Water rights in California are property rights, and surface or groundwater users may bring takings claims if they believe regulatory restrictions on use have effectively taken their property. However, inherent in those rights is susceptibility to reasonable regulation. GSAs can reduce the risk of takings liability by managing groundwater in a manner generally consistent with California water rights.
Public Trust Doctrine	If groundwater pumping within a GSA’s jurisdiction draws water from aquifers that are tributary to surface waterways, the public trust doctrine is likely to be relevant.
Federal and State Endangered Species Acts (CESAs)	Endangered species laws apply to groundwater allocation decisions that may impact listed species. GSAs seeking to avoid consequences under the ESA should be aware of these species within the basin and explicitly address their needs when developing GSPs.
California Environmental Quality Act (CEQA)	The preparation and adoption of GSPs is specifically exempt from CEQA. However, implementation actions taken by a GSA under a GSP would remain subject to CEQA. Compliance with CEQA would include analyzing and mitigating potential negative impacts on interconnected surface waters.
Clean Water Act and Porter-Cologne Act	Although water quality is also addressed separately within SGMA, it is relevant to groundwater-surface water interactions, including through effects on streamflow volume and temperature.
Instream flow requirements	To avoid significant and unreasonable adverse impacts on surface water, minimize risk of litigation <sup>^</sup> and maximize their GSPs’ defensibility. GSAs will need to be aware of instream flow requirements set by the State Water Resources Control Board and consider them when developing and implementing GSPs.

Source: Cantor et al. (2018)

consistent with a stream’s beneficial uses. SGMA effectively extends those responsibilities to GSAs to the degree that surface water depletion by groundwater pumping may affect water quality (including temperature) and species protected under ESA.

- the public trust doctrine has recently been affirmed by California courts to apply not only to surface water diversions, but also to groundwater pumping that

reduces instream flows in navigable rivers. The state (and, by extension, GSAs) must consider their public trust duty, which is not pre-empted by SGMA. Most significantly, perhaps, the public trust doctrine, ESA, and CWA do not waive the need for addressing pre-existing undesirable conditions – conditions that existed prior to 2014. While SGMA itself only requires that new post-2014 undesirable results be avoided, SGMA explicitly does not exempt or supercede any existing law.<sup>32</sup> The latter may mean that GSPs need to consider groundwater pumping impacts on surface water that have existed already for decades.

The role of GSAs in managing the water quality sustainability indicator similarly remains uncertain. Regional Water Boards (RWBs) already have extensive regulatory powers to protect both surface water and groundwater quality. At a minimum, GSAs will be required to take an active role in understanding existing water quality and the potential impacts of groundwater management projects and actions on future water quality. This will necessitate significant data collection and data management, assessment, and monitoring, possibly in collaboration with RWBs. Some GSA projects may require permits from the respective RWB, particularly for some recharge projects.

It remains to be seen how much technical assistance and legal guidance GSAs will receive from the state to support these efforts. But the water quality and groundwater-surface water interaction sustainability indicators, for the first time, will greatly expand the scope of groundwater management and require active engagement of the GSAs with a wide range of local, regional, state, and possibly federal agencies. Thus, GSP development, at its best, offers an opportunity to be the catalyst for comprehensive integrated regional water management planning and implementation across groundwater and surface water, across water supply and water quality, and across water and land use management.

## References

- Blomquist, W. (1992). *Dividing the waters: Governing ground water in Southern California*. San Francisco, 415 p.
- Brush, C. F., Dogrul, C., & Kadir, T. N. (2013). *Development and calibration of the California Central Valley groundwater-surface water simulation model (C2VSIM), Version 3.02-CG*. Sacramento, CA: DWR Technical Memorandum, California Department of Water Resources. [https://water.ca.gov/-/media/DWR-Website/Web-Pages/Library/Modeling-And-Analysis/C2VSim/Files/Coarse-Grid-C2VSim-Model-Version-R374\\_rev-C2VSim-CG\\_R374\\_rev-Released-April-27-2018/C2VSim\\_Model\\_Report\\_2016-03\\_vR374.pdf?la=en&hash=532C0F1BE59C6FE587D81B9250FC18D845FC38C6](https://water.ca.gov/-/media/DWR-Website/Web-Pages/Library/Modeling-And-Analysis/C2VSim/Files/Coarse-Grid-C2VSim-Model-Version-R374_rev-C2VSim-CG_R374_rev-Released-April-27-2018/C2VSim_Model_Report_2016-03_vR374.pdf?la=en&hash=532C0F1BE59C6FE587D81B9250FC18D845FC38C6). Accessed 18 Dec 2018
- California Department of Water Resources (CDWR). (2014). California Water Plan Update 2013, Volume 1, Chapter 3 (California Water Today), 115 p. <https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Water-Plan-Updates/Files/Update-2013/Water-Plan-Update-2013-Volume-1.pdf>. Accessed 18 Dec 2018.

---

<sup>32</sup> California Water Code §10726.8(a)

- California Department of Water Resources (CDWR). (2017). *Draft sustainable management criteria BMP*, 38 p. <https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT.pdf>. Accessed 18 Dec 2018.
- California Department of Water Resources (CDWR). (2018). *Flood-MAR: Using flood water for managed aquifer recharge to support sustainable water resources*. Sacramento, 56p. [https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/Flood-MAR/DWR\\_FloodMAR-White-Paper\\_06\\_2018\\_updated.pdf?la=en&hash=350DBD68452230C5CF1706C3E8EB1E3E613C25](https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/Flood-MAR/DWR_FloodMAR-White-Paper_06_2018_updated.pdf?la=en&hash=350DBD68452230C5CF1706C3E8EB1E3E613C25). Accessed 18 Dec 2018.
- Cannon Leahy, T. (2016). Desperate Times Call for Sensible Measures: The Making of the California Sustainable Groundwater Management Act, 9 Golden Gate U. Envtl. L.J. 5. <http://digitalcommons.law.ggu.edu/gguelj/vol9/iss1/4>. Accessed 18 Dec 2018.
- Cantor, A., Owen, D., Harter, T., Green Nysten, N., & Kiparsky, M. (2018). *Navigating groundwater-surface water interactions under the Sustainable Groundwater Management Act*. Berkeley, CA: Center for Law, Energy & the Environment, UC Berkeley School of Law, 50 p. <https://doi.org/10.15779/J23P87>. Accessed 18 Dec 2018
- Consolidated Irrigation District. (2009). Groundwater Management Plan, 137 p. [http://kings-groundwater.info/\\_documents/GWMPs/CID\\_SB1938\\_GWMP.pdf](http://kings-groundwater.info/_documents/GWMPs/CID_SB1938_GWMP.pdf). Accessed 18 Dec 2018.
- Dahlke, H. E., Brown, A., Orloff, S., Putnam, D., & O'Geen, T. (2018a). Managed winter flooding of alfalfa recharges groundwater with minimal crop damage. *California Agriculture*, 72(1), 65–75.
- Dahlke, H. E., LaHue, G. T., Mautner, M. R. L., Murphy, N. P., Patterson, N. K., Waterhouse, H., Yang, F., & Foglia, L. (2018b). Managed aquifer recharge as a tool to enhance sustainable groundwater management in California: examples from field and modeling studies. In J. Friesen & Rodriguez-Sinobas (Eds.), *Advanced tools for integrated water resources management volume 3: Advances in chemical pollution, environmental management and protection* (pp. 215–276).
- Fogg, G. E., & Bernacchi, L. (Eds.) (2018). *Recharge roundtable call to action: Key steps for replenishing California groundwater*, 27p. <http://ucwater.org/recharge>. Accessed 18 Dec 2018.
- Hanak, E., Escrivá-Bou, A., Gray, B., Green, S., Harter, T., Jezdimirovic, J., Lund, J., Medellin-Azuara, J., Moyle, P., & Seavy, N. (2019). *Water and the future of the San Joaquin Valley*. San Francisco, CA: Public Policy Institute of California, 100 p. <https://www.ppic.org/publication/water-and-the-future-of-the-san-joaquin-valley/>. Accessed 22 Nov 2019
- Hanak, E., Lund, J., Dinar, A., Gray, B., Howitt, R., Mount, J., et al. (2011). *Managing California's water: From conflict to reconciliation*. San Francisco, CA: Public Policy Institute of California. [https://www.ppic.org/content/pubs/report/R\\_211EHR.pdf](https://www.ppic.org/content/pubs/report/R_211EHR.pdf). Accessed 18 Dec 2018
- Hanak, E., & Stryjewski, E. (2012). *California's water market, By the numbers: Update 2012*, 48 p. [http://www.ppic.org/content/pubs/report/R\\_1112EHR.pdf](http://www.ppic.org/content/pubs/report/R_1112EHR.pdf). Accessed 18 Dec 2018.
- Harter, T., & Dahlke, H. E. (2015). Out of sight but not out of mind: California refocuses on groundwater. *California Agriculture*, 68(3), 54–55.
- Kocis, T. N., & Dahlke, H. E. (2017). Availability of high-magnitude streamflow for groundwater banking in the Central Valley, California. *Environmental Research Letters*, 12(8), 084009.
- Langridge, R., Brown, A., Rudestam, K., & Conrad, E. (2016a). *An evaluation of California's adjudicated groundwater basins*, Report to the State Water Resources Control Board, 272 p. [https://www.waterboards.ca.gov/water\\_issues/programs/gmp/docs/resources/swrcb\\_012816.pdf](https://www.waterboards.ca.gov/water_issues/programs/gmp/docs/resources/swrcb_012816.pdf). Accessed 18 Dec 2018.
- Langridge, R., Sepaniak, S., & Conrad, E. (2016b). *An evaluation of California's special act districts*, Report to the State Water Resources Control Board, 183 p. <https://escholarship.org/uc/item/3cr8k66v>. Accessed 18 Dec 2018.
- Legislative Analyst's Office (LAO). (2002). [https://lao.ca.gov/2002/water\\_districts/special\\_water\\_districts.html](https://lao.ca.gov/2002/water_districts/special_water_districts.html). Accessed 18 Dec 2018.

- Lipson, A. (1979). *Efficient water use in California: The evolution of groundwater management in Southern California*, Rand Report R-2387/2-CSA/RF, ISBN 0-8330-0135-3. <https://www.rand.org/content/dam/rand/pubs/reports/2009/R2387.2.pdf>. Accessed 18 Dec 2018.
- Matthews, O. P. (2003). Simplifying western water rights to facilitate water marketing. *UCOWR Water Resources Update*, 126, 40–44.
- Nelson, R. (2011). *Uncommon innovation: Developments in groundwater management planning in California*. Stanford University. 43 p. <http://waterinthewest.stanford.edu/resources/publications-directory/uncommon-innovation-developments-groundwater-management-planning>. Accessed 18 Dec 2018.
- Niswonger, R. G., Morway, E. D., Triana, E., & Huntington, J. L. (2017). Managed aquifer recharge through off-season irrigation in agricultural regions. *Water Resources Research*, 53, 6970–6992. <https://doi.org/10.1002/2017WR020458>
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. New York, NY: Cambridge University Press.
- Owen, D., Cantor, A., Green-Nylen, N., Harter, T., & Kiparsky, M. (2019). California groundwater management, science-policy interfaces, and the legacies of artificial legal distinctions. *Environmental Research Letters*, 14(4). <https://iopscience.iop>. <https://doi.org/10.1088/1748-9326/ab0751>
- Palazzo, J., Liu, O. R., Stillinger, T., Song, R., Wang, Y., Hiroyasu, E. H. T., et al. (2017). Urban responses to restrictive conservation policy during drought. *Water Resources Research*, 53, 4459–4475. <https://doi.org/10.1002/2016WR020136>
- Reisner, M. (1993). *Cadillac desert*. Penguin USA. 582 p.
- Sax, J. L. (2002). We Don't do groundwater: A morsel of California legal history. *University of Denver Water Law Review*, 6, 269. <https://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=2394&context=facpubs>. Accessed 18 Dec 2018
- Schneider, A. (1977). Groundwater Rights in California: Background and Issues, Governor's Commission to Review California Water Rights Law Staff Paper No. 2. [https://ia600501.us.archive.org/32/items/GovernorsCommissionMemos/Govcomm-GwRights\\_text.pdf](https://ia600501.us.archive.org/32/items/GovernorsCommissionMemos/Govcomm-GwRights_text.pdf). Accessed 18 Dec 2018.
- Wrzesien, M. L., Durand, M. T., Pavelsky, T. M., Howat, I. M., Margulis, S. A., & Huning, L. S. (2017). Comparison of methods to estimate snow water equivalent at the mountain range scale: A case study of the California Sierra Nevada. *Journal of Hydrometeorology*, 18(4), 1101–1119.

**Thomas Harter** is the Robert M. Hagan Endowed Chair in Water Management and Policy within the hydrology program in the Department of Land, Air, and Water Resources. Thomas Harter has a B.S. in hydrology from the University of Freiburg, Germany and a M.S. in hydrology from the University of Stuttgart, Germany. He received his Ph.D. in hydrology (with emphasis on subsurface hydrology) at the University of Arizona. In 1995, he joined the faculty at the Department of Land, Air, and Water Resources, University of California, Davis. His research focuses on nonpoint-source pollution of groundwater, sustainable groundwater management, groundwater modeling, groundwater resources evaluation under uncertainty, groundwater-surface water interaction, and on contaminant transport. Dr. Harter's research group has done extensive modeling, laboratory, and field work to evaluate the impacts of agriculture and human activity on groundwater flow and contaminant transport in complex aquifer and soil systems. In 2007, Dr. Harter was appointed Robert M. Hagan Endowed Chair in Water Management and Policy. Also in 2008, Dr. Harter's research and extension program received the Kevin J. Neese Award in recognition of its efforts to engage scientists, regulators, farm advisors, dairy industry representatives, and dairy farmers to better understand the effects of dairy operations on water quality.