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Trading Sustainably:

CRITICAL CONSIDERATIONS FOR LOCAL GROUNDWATER MARKETS UNDER THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

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Review

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We are grateful for their efforts. Their constructive comments and suggestions helped us improve the report. Responsibility for its final content rests entirely with the authors. Any errors are our own.

About the authors

Nell Green Nylen is a Senior Research Fellow with the Wheeler Water Institute. Her research engages law, science, and policy to tackle critical water issues. Dr. Green Nylen has also published on the legal and environmental implications of federal agency planning and decision making. Before becoming a Research Fellow, she clerked for Justice Gregory J. Hobbs, Jr., of the Colorado Supreme Court and interned with the California Attorney General's Office and the Center for Biological Diversity. She earned a J.D. from UC Berkeley School of Law, and both a Ph.D. and a B.S. in Geological and Environmental Sciences from Stanford University, where her dissertation examined past climatic and environmental change along the Northern California coast.

Michael Kiparsky is the founding Director of the Wheeler Water Institute within the Center for Law, Energy & the Environment at the UC Berkeley School of Law, and a co-Director of the UC Water Security and Sustainability Research Initiative (UC Water). Under his leadership, the Institute has grown into a widely-recognized voice on a range of California water issues. Dr. Kiparsky has worked on technical and policy aspects of water resources management for 15 years, and his primary interest lies at their intersection. He has published academic articles and technical reports on a range of topics including governance and policy of complex water systems, climate change impacts and adaptation, water innovation, and science for decision-making. His work has appeared in media outlets including The Sacramento Bee, the San Francisco Chronicle and the Los Angeles Times, and through his engagement activities is regularly used by state and local decision-makers. He was previously on the faculty at the University of Idaho, and has experience in consulting, non-profit, and agency settings. Dr. Kiparsky earned an A.B. in Biology from Brown University and a Ph.D. from UC Berkeley's Energy and Resources Group, where he was an NSF Graduate Research Fellow, a Udall Scholar, a CALFED Science Scholar, and the first ACWA Steve Hall Water Law & Policy Scholar. He was recently named one of "Nine Experts to Watch on California Water Policy" by Water Deeply.

Kelly Archer was an undergraduate research assistant at the Wheeler Water Institute. She has since completed her B.S. in Environmental Engineering at UC Berkeley. Kelly's passion lies at the interface between engineering, public health, law, and public policy. Thus, her research experience ranges across disciplines including air quality engineering, hydrology, water law and policy, and agricultural geochemistry.

Kurt Schnier is a Professor of Economics at the University of California, Merced. His research focuses on environmental and health economics. He has published on the utilization of property rights to manage natural resources, efficient market structure for water pollution markets, the impact of spatial regulations in marine fisheries, and the efficient utilization of health care resources. Before joining the faculty at the University of California, Merced, he served on the faculty at Georgia State University and the University of Rhode Island. He earned his Ph.D. from the University of Arizona, a M.A. in Environmental Studies from the University of Pennsylvania, and a B.S. in Management Sciences from the University of California, San Diego.

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The Wheeler Water Institute develops interdisciplinary solutions to ensure clean water for California. Established in 2012 at the Center for Law, Energy & the Environment (CLEE) at Berkeley Law, the Institute conducts projects at the intersection of law, policy and science.

The Center for Law, Energy & the Environment (CLEE) at Berkeley Law educates the next generation of environmental leaders and develops policy solutions to pressing environmental and energy issues. The Center's current initiatives focus on reducing greenhouse gas emissions, advancing the transition to renewable energy, and ensuring clean water for California's future.

Table of contents

List of boxes

List of tables

List of figures

Abbreviations used in this report

Basin	Alluvial groundwater basin or subbasin identified in DWR's Bulletin 118
CEQA	California Environmental Quality Act
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
GDE	Groundwater dependent ecosystem
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
NEPA	National Environmental Policy Act
SGMA	Sustainable Groundwater Management Act
SWRCB	State Water Resources Control Board

Executive Summary

The Sustainable Groundwater Management Act (SGMA), passed in 2014, is changing the way California manages its groundwater resources. SGMA calls for the creation of local Groundwater Sustainability Agencies (GSAs) and tasks them with developing and implementing Groundwater Sustainability Plans (GSPs) to achieve sustainable groundwater management. SGMA offers GSAs a broad palette of tools to choose from and significant flexibility to tailor their management activities to local conditions and needs. Because it allows GSAs to assign groundwater extraction allocations to pumpers and to authorize transfers of these allocations under certain circumstances, SGMA potentially opens the door for the development of local groundwater markets. In such a market, a willing seller might trade a portion of their groundwater extraction allocation to a willing buyer, allowing the buyer to pump groundwater in the seller's stead.

In concept, markets can be used as tools to efficiently achieve specific management objectives. For example, in some areas, local groundwater markets could potentially further sustainable management under SGMA. However, this will not be the case in every groundwater basin. Used inappropriately, groundwater markets could have unintended consequences, including harmful social and environmental impacts. Where GSAs decide to employ local groundwater markets, careful design and implementation will be critical to ensuring their success.

The stakes involved in SGMA implementation are high. Groundwater is a common-pool resource: extractions by one user in one place affect the resource at large and, therefore, the ability of others to use the resource. Changing where or when groundwater is pumped or the place, method, timing, or purpose of its use can change the impacts experienced by people and ecosystems. Groundwater management decisions made today will affect everyone in a basin, now and well into the future. The full impacts of poor decisions may not be felt until long after they are made, and some impacts may be irreversible.

Therefore, this report outlines a set of considerations GSAs will need to examine when evaluating whether a local groundwater market might be a viable tool for furthering sustainable management in a particular groundwater basin, and, if so, how to effectively implement it.

SGMA requires local agencies to sustainably manage groundwater resources

SGMA requires the formation of GSAs in medium- and high-priority groundwater basins. It tasks them with developing and implementing GSPs to achieve sustainability within 20 years of plan implementation. Sustainable management avoids six undesirable results: significant and unreasonable (1) depletion of groundwater supply, indicated by chronic lowering of groundwater levels, (2) reduction of groundwater storage, (3) seawater intrusion, (4) degraded water quality, (5) land subsidence, and (6) adverse impacts on beneficial uses of interconnected surface water.

SGMA potentially opens the door for local groundwater markets based on within-GSA transfers of groundwater extraction allocations

SGMA offers GSAs a broad palette of tools for achieving sustainability. For example, GSAs can limit groundwater pumping by establishing groundwater extraction allocations for groundwater users within their jurisdictions. SGMA allows GSAs to then authorize transfers of these allocations when the total amount of groundwater pumped within the basin is consistent with the applicable GSP. Beyond these basics, SGMA does not provide guidance about the circumstances under which specific transfers, or a transfer program more generally, might be useful and appropriate additions to GSAs' sustainability programs. Although transfers of groundwater extraction allocations could be used in other ways, this report focuses on the possibility that they could be used as the basis for local groundwater markets that enable water users to voluntarily redistribute basin groundwater resources among themselves.

In some areas, carefully designed and implemented groundwater markets might further sustainable management

A central argument advanced by market proponents is that markets enable the reallocation of limited resources more efficiently than other mechanisms, including regulations alone. GSAs in many groundwater basins, including those that are critically overdrafted, will need to limit pumping to address unsustainable groundwater use. Limits will affect individual and collective incentives for groundwater use, potentially making some past uses of groundwater less feasible and leading to changes in where and how groundwater is used. Groundwater markets would affect these incentives more explicitly.

Carefully designed and implemented local groundwater markets could potentially contribute to socially, environmentally, and economically desirable reallocation of groundwater resources in some basins, but success is not a foregone conclusion. Markets (like all management tools) can have externalities—unintended or incidental effects on third parties or the environment that result from market transactions. Transfers of groundwater extraction allocations change where groundwater is pumped and where and how it is used, potentially changing its social and environmental impacts. Unrestricted or poorly administered transfers could result in significant negative externalities, including the undesirable results SGMA requires GSAs to avoid.

Whether a local groundwater market might be a viable tool for furthering sustainability in a particular basin will depend on a host of factors. These include applicable laws and regulations, basin conditions (and the state of knowledge about basin conditions), market design, and market implementation. In some areas, groundwater markets may not be viable management options: for example, where the potential impacts of trading are not well understood, where trading rules cannot sufficiently address negative externalities, or where—relative to other management options—the expected benefits of a market do not outweigh the burdens and uncertainties associated with designing and implementing it. However, in other areas, local groundwater markets may have the potential to not only further sustainable groundwater management but to contribute significant sustainability benefits. Careful design and implementation will be needed to guard against harmful side effects.

Critical considerations for local groundwater markets that further sustainable management under SGMA

Information provides the foundation for good decision making. GSAs and the stakeholders they serve should analyze potential management options and compare their expected benefits and burdens. Factors like local climate, geology, hydrology, ecological resources and needs, legal requirements, social and economic conditions, and goals will affect these analyses. These factors may vary significantly from basin to basin and within a single basin.

This report outlines a set of considerations designed to help GSAs and others evaluate whether a local groundwater market based on transfers of groundwater extraction allocations might be a viable management tool.

We organize these considerations into three groups:

1. **Foundational considerations** — Because local groundwater markets under SGMA would be based on transfers of groundwater extraction allocations, GSAs need to analyze a set of foundational considerations shared in common with other programs that limit groundwater pumping. These considerations relate to measuring groundwater extractions, setting overall pumping limits for basins and basin management areas, and establishing individual groundwater extraction allocations.
2. **Market-specific considerations** — A number of additional considerations are relevant for local groundwater markets based on transfers of groundwater extraction allocations. These considerations relate to market goals, groundwater rights questions, the potential impacts of trading, trading rules, and the trading system and transfer approval process. Carefully designed rules will be needed to ensure that trades support progress toward sustainability and sufficiently address negative impacts to third parties and the environment.
3. **General considerations** — Some considerations are important for all groundwater sustainability programs. For example, GSAs will need to establish and maintain monitoring systems that help them understand how program activities affect basin conditions. They will need to exercise oversight and enforcement authority to ensure compliance with program requirements, evaluate program effectiveness, and address problems by making needed changes. Transparency and public engagement will be important throughout. Finally, developing and implementing sustainability programs will require sufficient resources, including human capacity, physical and technological infrastructure, and funding.

When discussing these considerations, the report points out legal ambiguities and other sources of uncertainty that may present challenges for those seeking clarity about market programs. GSAs should consider the relationship between groundwater extraction allocations and groundwater rights. They should ask whether and how differences in the characteristics of groundwater rights should be accounted for in the allocation process and whether and how these differences should affect transferability. Robust public engagement may help GSAs navigate these issues successfully, while failing to address them adequately could prompt an adjudication or lay the groundwork for water right takings claims.

Developing and implementing local groundwater markets that successfully further sustainable management under SGMA will require significant effort. We hope the considerations outlined in this report help GSAs and others evaluate whether such markets might be viable local management tools and, if so, how to effectively implement them.

I. Introduction

In many California groundwater basins, past levels and patterns of groundwater extraction and use are unsustainable. A few examples:

- Excessive pumping has depressed groundwater levels and caused subsidence to occur over large areas of the Central Valley, including nearly 2 feet of subsidence between May 2015 and September 2016 in some areas.[1]
- In the Salinas groundwater basin, over-pumping has caused seawater to intrude up to 11 kilometers into the coastal aquifer system.[2]
- Pumping near the Scott River has contributed to reduced, warmer base flow during summer and fall that poses risks for salmon that spawn there.[3]

The Sustainable Groundwater Management Act (SGMA), passed in 2014, is changing the way California manages its groundwater resources. SGMA calls for the creation of local Groundwater Sustainability Agencies (GSAs) and tasks them with developing and implementing Groundwater Sustainability Plans (GSPs) to achieve sustainable groundwater management. SGMA offers GSAs a broad palette of tools to choose from and significant flexibility to tailor their management activities to local conditions and needs.

Because it allows GSAs to assign groundwater extraction allocations to pumpers and to authorize transfers of these allocations under certain circumstances, SGMA could open the door for local groundwater markets.

A major reason SGMA gives GSAs broad flexibility to decide how to bring basin groundwater use into alignment with sustainable yield is that there is no single best way to accomplish this goal that will work in every basin. Indeed, for each basin, there may be many possible approaches to achieving sustainability. The way stakeholders experience SGMA implementation will be path dependent: it will depend on the specific choices a GSA makes. When weighing different approaches, then, GSAs will want to consider things like which are likely to achieve sustainability more quickly, to be less burdensome for different groups of stakeholders, to be more likely to avoid negative unintended consequences, and to be less resource intensive.

GSAs in many groundwater basins, especially those identified as critically overdrafted, will need to limit pumping to address unsustainable groundwater use. Limits will affect individual and collective incentives for groundwater conservation, replenishment, and use, potentially making some past uses less feasible and driving changes in where and how groundwater is used. Changing groundwater use patterns by reallocating limited groundwater resources among existing uses, and between existing and new uses, may help water users adapt to new constraints.[4]

By facilitating the movement of water from willing sellers to willing buyers, a market-based approach could enable more economically efficient reallocation than a purely regulatory approach.[5] In some areas, local groundwater markets based on transfers of groundwater extraction allocations could potentially further sustainable management under SGMA. However, this will not be the case in every basin, and GSAs have other tools they can use to provide incentives for reallocating groundwater extraction and use (**Box 1**).

Where GSAs decide to employ local groundwater markets, careful design and implementation will be critical to ensuring their success as sustainable management tools. Used inappropriately, markets could have harmful unintended consequences, including contributing to the undesirable results SGMA seeks to avoid.

The stakes involved in SGMA implementation are high. Groundwater management decisions made today will affect everyone in a basin, now and well into the future. The full impacts of poor decisions may not be felt until long after they are made, and some impacts may be irreversible.

Therefore, this report outlines a set of considerations GSAs will need to examine when evaluating whether local groundwater markets might be viable management tools in their groundwater basins, and, if so, how to effectively implement them.

BOX 1. Other mechanisms for reducing or reallocating groundwater extraction and use

Although this report focuses on local groundwater markets based on transfers of groundwater extraction allocations, other mechanisms for reducing or reallocating groundwater extraction and use are potentially available under SGMA. These include:

Establishing direct or indirect extraction limitations

SGMA allows GSAs to directly restrict pumping.[6] Other, more indirect, methods of reducing groundwater use are theoretically possible, like limiting the amount of irrigated acreage allowed in a basin or imposing crop water allowances.[7] If not designed with care, indirect limitations might be counterproductive, for example, by giving farmers incentives for switching to higher value, more water intensive crops that harden demand, not for reducing their groundwater usage. Compliance with indirect limitations may also be more difficult to measure.

Requiring new development projects to offset groundwater use

GSAs with land use planning authorities (counties and cities) could require proponents of development projects to take measures that reduce existing groundwater use to achieve "no net increase" in the amount of groundwater extracted in the area.[8]

Imposing fees for groundwater extraction

Appropriately designed groundwater extraction fees cover groundwater management expenses and have the side benefit of providing a financial incentive for reducing groundwater use. Reallocation might occur as some users decide not to maintain, or to reduce, their past groundwater use in light of increased costs. SGMA authorizes GSAs to impose fees to support their activities, subject to some, not yet fully understood, limitations.[9]

- **Volumetric fees** — Whether or not they are accompanied by direct restrictions on pumping, fees based on the amount of groundwater pumped may encourage pumping reductions. Orange County Water District[10] and Pajaro Valley Water Management Agency[11] are examples of agencies that impose volumetric fees.
- **Allocation-related fees** — A fee structure linked to hard or soft groundwater extraction allocations might conceivably include lower fees or credits for those who pump less than their allocated amount and higher fees (e.g., replenishment charges) or penalties for those who exceed their pumping allocation. Allocation-related fees have been used by Fox Canyon Groundwater Management Agency,[12] Orange County Water District,[13] and the City of Salinas,[14] as well as imposed through adjudications.[15]
- **Project-based fee rebates** — Fee rebates can provide incentives for landowners to undertake suitable groundwater recharge projects. An example is Pajaro Valley Water Management Agency's Recharge Net Metering pilot program.[16]

Providing alternative water supplies

SGMA authorizes GSAs to provide pumpers with water from alternative sources (e.g., imported water, local surface water, local reclaimed water) in exchange for their agreement to cease or reduce groundwater extractions.[17] Agencies that provide alternative supplies include Semitropic Water Storage District[18] and Pajaro Valley Water Management Agency.[19] This option is more likely to be effective when combined with appropriately designed groundwater extraction fees.

A. Who should read this report?

We provide information and analysis that may be useful to a range of audiences:

GSAs considering implementing local groundwater markets

GSAs are responsible for developing and implementing sustainability programs to avoid undesirable results. This report can help GSAs evaluate whether a local groundwater market based on transfers of groundwater extraction allocations might be a viable tool for achieving sustainability in a particular basin and, if so, what such a program would entail. It can help GSAs begin to think through the potential benefits and burdens associated with designing and implementing a successful market-based program so that they can appropriately prioritize markets within a portfolio of potential management actions.

Stakeholders affected by groundwater management

Stakeholders with diverse interests will be affected, directly or indirectly, by GSA's groundwater management decisions. They include parties with groundwater or surface water rights; Native American tribes; disadvantaged communities; local, state, and federal agencies with land use, water supply, water quality, or wildlife protection responsibilities; and third parties interested in maintaining or enhancing environmental flows.[20] This report can help various stakeholders gauge how local groundwater markets might affect the things they care about and identify what market-related questions and issues they want to see thoroughly explored during the planning, development, and implementation of sustainability programs.

State agencies with groundwater management responsibilities

The Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) have important oversight and intervention responsibilities under SGMA. This report can help these agencies assess whether a particular GSA's reliance on a local groundwater market is appropriate and, if so, whether it has adopted and implemented trading rules and other requirements that adequately address basin conditions and potential trading impacts.

B. Report organization

This Part, **Part I** gives a brief introduction to the concept of local groundwater markets under SGMA, explains who may find this report useful, and summarizes the report's organization.

Part II provides legal, institutional, and physical context for local groundwater markets. First, it summarizes SGMA's requirements for sustainably managing groundwater, presents SGMA's definition of sustainability, explains SGMA's applicability, and identifies the major tools GSAs can use to achieve sustainable management. Next it explains how SGMA opens the door for local groundwater markets based on transfers of groundwater extraction allocations and gives a brief overview of existing groundwater (and groundwater-related) markets. Finally, it discusses potential market impacts and introduces critical considerations for local groundwater markets under SGMA.

Parts III, IV, and V outline a set of considerations designed to help GSAs and others evaluate whether a local groundwater market based on transfers of groundwater extraction allocations might be a viable management tool.

We organize these considerations into three groups:

- **Foundational considerations** — Because local groundwater markets under SGMA would be based on transfers of groundwater extraction allocations, GSAs need to analyze a set of foundational considerations shared in common with other programs that limit groundwater pumping. These considerations relate to measuring groundwater extractions, setting overall pumping limits for basins and basin management areas, and establishing individual groundwater extraction allocations.
- **Market-specific considerations** — A number of additional considerations are relevant for local groundwater markets based on transfers of groundwater extraction allocations. These considerations relate to market goals, groundwater rights questions, the potential impacts of trading, trading rules, and the trading system and transfer approval process. Carefully designed rules will be needed to ensure that trades support progress toward sustainability and sufficiently address negative impacts to third parties and the environment.
- **General considerations** — Some considerations are important for all groundwater sustainability programs. For example, GSAs will need to establish and maintain monitoring systems that help them understand how program activities affect basin conditions. They will need to exercise oversight and enforcement authority to ensure compliance with program requirements, evaluate program effectiveness, and address problems by making needed changes. Transparency and public engagement will be important throughout. Finally, developing and implementing sustainability programs will require sufficient resources, including human capacity, physical and technological infrastructure, and funding.

When discussing these considerations, the report points out legal ambiguities and other sources of uncertainty that may present challenges for those seeking clarity about market programs. For example, GSAs will need to consider the relationship between groundwater extraction allocations and groundwater rights, asking whether and how differences in the characteristics of groundwater rights should be accounted for in the allocation process and whether and how these differences should affect transferability. Robust public engagement may help GSAs navigate these issues successfully, while failing to address them adequately could prompt an adjudication or lay the groundwork for water right takings[21] claims.

Part VI summarizes our main conclusions and observations.

II. Context for local groundwater markets under SGMA

Local groundwater markets under SGMA will occur within specific legal, institutional, and physical contexts. SGMA requires GSAs to sustainably manage groundwater resources. It offers these local agencies a broad palette of tools to choose from and significant flexibility to tailor their management activities to local conditions, needs, and goals. Because SGMA allows GSAs to assign groundwater extraction allocations to pumpers and to authorize transfers of these allocations under certain circumstances, it potentially opens the door for local groundwater markets.

A. SGMA requires local agencies to manage groundwater sustainably

California's historic, ongoing drought has highlighted the importance of groundwater resources to state and local water security, driving the first statewide mandate for groundwater management. Although earlier legislation supported various local sustainability efforts,[22] SGMA created the first systematic statewide requirement to sustainably manage groundwater. It sets a state policy of managing groundwater resources "for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses."[23] Although both local and state agencies play important roles in operationalizing this policy and related requirements, primary management responsibilities lie with local public agencies.[24]

SGMA calls for the formation of one or more local Groundwater Sustainability Agencies (GSAs) in designated basins around the state.[25] GSAs must develop and implement effective Groundwater Sustainability Plans (GSPs)[26] that include measurable objectives with interim milestones designed to achieve sustainable management within 20 years of plan implementation.[27] If multiple GSAs develop multiple plans in a particular basin, they must jointly coordinate implementation and jointly submit the plans to DWR for evaluation.[28]

Sustainability defined

Sustainable groundwater use avoids unacceptable long-term environmental, economic, or social consequences.[29] SGMA defines sustainable management[30] in terms of avoiding six undesirable results:

(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. 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.[31]

Sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result."[32]

Applicability

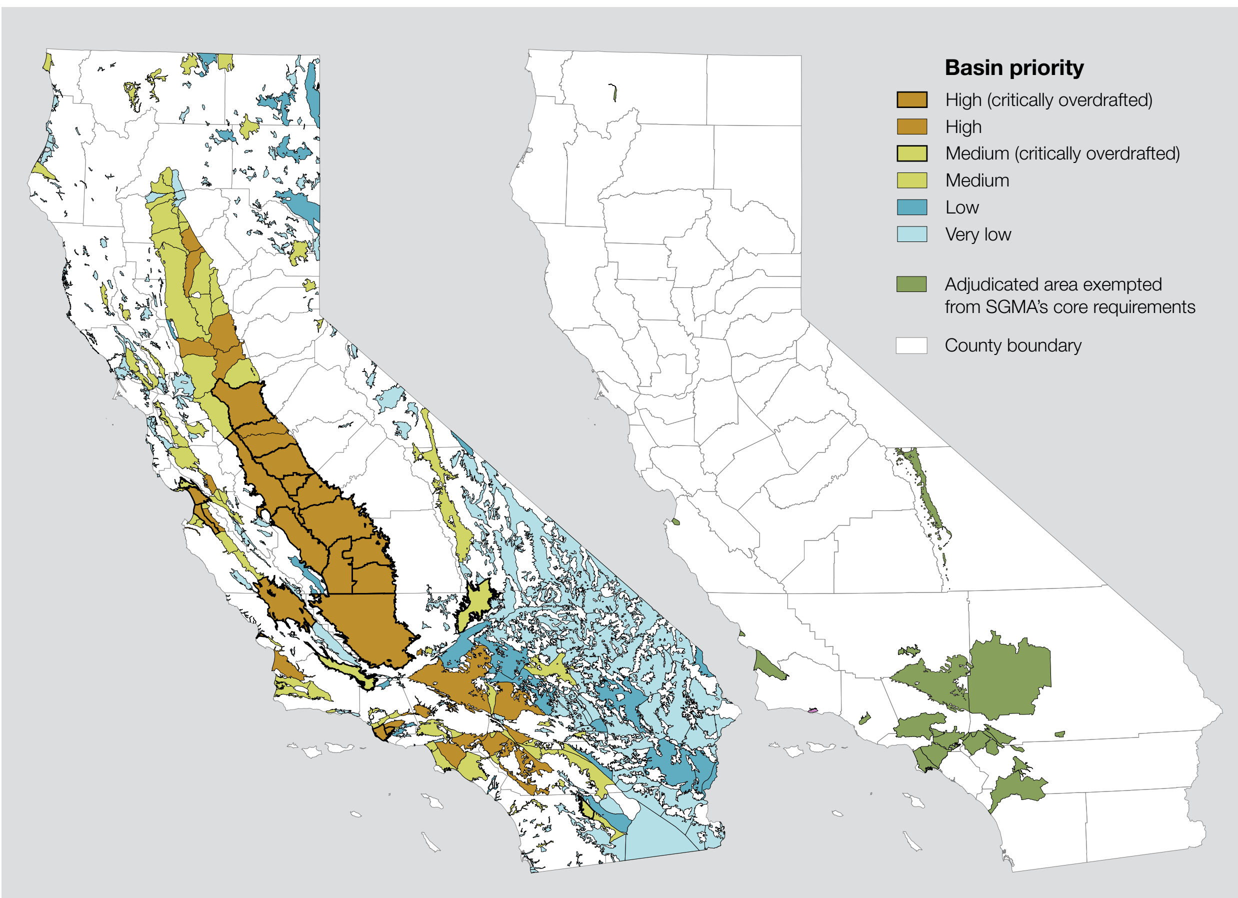
Instead of applying uniformly across the state, SGMA takes a more targeted approach by establishing mandatory requirements for sustainably managing those basins and subbasins (hereinafter "basins") that DWR designates as medium or high priority.[33] Collectively, these basins account for an estimated 96% of all groundwater pumping statewide each year.[34] As of September 2016, they included 127[35] of the 515 alluvial basins DWR defined in its 2003 Update to Bulletin 118, California's "official compendium on the occurrence and nature of groundwater" (**Figure 1**).[36]

Of these 127 basins, 21 were designated as critically overdrafted (shown with bold outlines in **Figure 1**).[37] Basin boundary modifications made in late 2016 have increased the total number of basins to 517.[38] Basin reprioritizations that take into account modified boundaries are expected to be complete by late 2017.[39]

SGMA exempts 29 listed adjudicated areas (**Figure 1, Box 2**) from its core requirements.[40] The exemption will not apply to areas that may be adjudicated in the future. Additionally, 2015 statutory changes should ensure that future adjudications are consistent with sustainable groundwater management under SGMA.[41]

State agencies have important guidance, oversight, and intervention responsibilities to assist and serve as a backstop for local management. These responsibilities are described more fully **Box 8**.

FIGURE 1. Groundwater basin priority, critically overdrafted basins, and exempted adjudicated areas.[42] SGMA requires medium- and high-priority basins and subbasins to be managed sustainably, while areas addressed by past groundwater adjudications are exempted from SGMA's core requirements. Critically overdrafted basins are shown with bold outlines. (NOTE: The basin boundaries shown here do not reflect 2016 boundary modifications, expected to be included in updated basin prioritizations by late 2017.[43])



Tools for sustainable management

GSAs have wide latitude to determine what tools to use to achieve sustainable management. SGMA provides a broad palette of potential authorities, coupled with significant flexibility to plan and implement locally tailored programs.[44] For example, GSAs can, but are not required to, do the following:

- **Improve information about basin demand** by requiring registration of groundwater extraction facilities within their management areas, mandating the use of water-measuring devices,[45] and requiring annual statements of groundwater extractions.[46]

- **Minimize well interference** by imposing "reasonable operating regulations on existing groundwater wells" and spacing requirements on the construction of new wells.[47]
- **Increase net groundwater supply** by appropriating surface water, importing water from outside the basin, or conserving water and using it for groundwater replenishment or providing it "in exchange for a groundwater extractor's agreement to reduce or cease groundwater extractions."[48]
- **Control groundwater extractions** "by regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate, construction of new groundwater wells, enlargement of existing groundwater wells, or reactivation of abandoned groundwater wells, or otherwise *establishing groundwater extraction allocations*."[49]

If they choose to establish groundwater extraction allocations, GSAs can then **authorize transfers** of these allocations under certain circumstances.[50]

B. SGMA opens the door for local groundwater markets

SGMA opens the door for local groundwater markets based on transfers of groundwater extraction allocations. GSAs can limit groundwater pumping by establishing allocations for groundwater users within their jurisdictions and authorize transfers of these allocations when the total amount of groundwater pumped within the basin is consistent with the applicable GSP. Beyond these basics, SGMA does not provide guidance about the circumstances under which specific transfers, or a transfer program more generally, might be useful and appropriate additions to GSAs' sustainability programs.

A brief overview of existing groundwater, and groundwater-related, markets provides more context.

1. Local groundwater markets under SGMA

Under SGMA, GSAs have the authority to "regulate groundwater extraction" by "authoriz[ing] temporary and permanent transfers of groundwater extraction allocations within the agency's boundaries."[51] GSA can also "establish accounting rules to allow unused groundwater extraction allocations … to be carried over from one year to another and voluntarily transferred."[52]

For the purposes of this report, we focus on local transfers that do not involve basin exports. The language of SGMA's transfer provisions suggests that a GSA cannot authorize transfers that would result in water users exercising groundwater extraction allocations outside the GSA's jurisdiction. It is unclear whether the legislature intended to allow groundwater to be pumped pursuant to a transferred groundwater extraction allocation within the GSA's jurisdiction and then transported outside its jurisdiction before use. We also realize that the extent of a GSA's jurisdiction will not necessarily correspond to the extent of a groundwater basin: some basins will be managed by a patchwork of coordinated GSAs, while some GSAs will manage all or parts of multiple basins.[53] However, many of the issues we discuss are most straightforward when considered on a basin level, given SGMA's focus on the basin as the primary unit of analysis.

Express and implied limitations on transfers of groundwater extraction allocations

SGMA specifically identifies three limitations on transfers of groundwater extraction allocations. First, they can only be authorized in a particular water year "if the total quantity of groundwater extracted … is consistent with the provisions of the [GSP]."[54] Second, GSAs can allow unused groundwater extraction allocations to be carried over and transferred only "if the total quantity of groundwater extracted in any five-year period is consistent with the provisions of the [GSP]."[55] Finally, SGMA clarifies that transfers are "subject to applicable city and county ordinances,"[56] some of which impose constraints on well construction or modification, groundwater exports, or other transfers (**Table 1**).[57]

However, GSAs need to consider other potential limits. First, a groundwater transfer program should be consistent with SGMA's other substantive and procedural requirements. GSAs bear responsibility for ensuring that their sustainability programs aid, and do not impede, sustainable management. In other words, transfers should not cause or contribute to the undesirable results SGMA requires GSAs to avoid. Second, transfer programs should adequately address other applicable local, state, and federal law (**Table 1**).

TABLE 1. Various legal requirements and restrictions may be relevant to groundwater markets based on transfers of groundwater extraction allocations. Where noted, further details are explored elsewhere in this report.

Requirement	Relevance
SGMA	Specific provisions explicitly limit transfers of groundwater extraction allocations, and SGMA's sustainability requirements implicitly limit them in other ways. (**Part II**)
Common-law groundwater rights	The California Constitution requires all water use to be beneficial and reasonable. There is no right to unreasonable use of water. (**Part III.C.3**) GSAs should consider whether and how they might account for differences in the characteristics of different types of groundwater rights when establishing related groundwater extraction allocations and making rules that govern their transferability. (**Parts III.C.4 and IV.B.2**) Water right changes—including changes in the point of diversion or extraction or the place, method, or purpose of use—should not injure other legal water users. (**Box 6** and **Appendix B**)
Area-of-origin statutes	State laws impose restrictions on groundwater exports from "protected areas,"[58] with heightened requirements for exports from parts of the Delta watershed.[59] These laws could come into play where the jurisdiction of a single GSA extends beyond the boundaries of one groundwater basin.
Local ordinances	Well construction or modification requires a county (or city) permit.[60] Approval can be made contingent on conditions like well-spacing requirements.[61] At times, local governments have temporarily stopped permitting new wells and modifications.[62] Some county ordinances impose hurdles to groundwater exports[63] or other changes in the place of use.[64] These restrictions could come into play where the jurisdiction of a single GSA extends beyond the boundaries of one county.
The Public Trust Doctrine	State courts and agencies must take public trust interests in navigable waterways and non-navigable streams into account and protect them whenever feasible.[65] Public trust concerns may be especially relevant for transfers of groundwater extraction allocations to areas where groundwater and surface water have obvious connections, e.g., where groundwater contributes to base flow in a stream with a salmon run.
The Human Right to Water Statute	This statute requires state agencies to consider how their actions, including those taken to implement SGMA, will affect "safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." GSAs will want to consider how DWR and the SWRCB might address the Human Right to Water in developing and updating policies and regulations that govern how they approach adequacy review of GSPs (and their implementation) and the timing, form, and substance of state intervention efforts. (**Box 7**)
Water quality requirements	The state Porter-Cologne Water Quality Control Act,[66] federal Clean Water Act,[67] and federal Safe Drinking Water Act[68] impose various water quality standards. Transfers of groundwater extraction allocations should not individually or cumulative cause or contribute to violations of these standards.
Wildlife and ecosystem protections	The federal[69] and state[70] Endangered Species Acts impose protections for threatened and endangered species and the ecosystems they depend upon. In some cases, instream flow requirements have been instituted to protect these species.[71] Transfers of groundwater extraction allocations should not individually or cumulatively cause or contribute to violations of these protections. SGMA, and DWR's related regulations, require GSPs to address impacts to groundwater dependent ecosystems.[72] GSAs will want to consider the potential impacts of trading on these ecosystems.
Environmental review requirements	The California Environmental Quality Act (CEQA) requires state and local agencies to evaluate the environmental impacts of proposed projects they have discretion over—which would include transfers of groundwater extraction allocations—and to mitigate or avoid significant impacts whenever feasible.[73]

Local groundwater markets would be based on transfers of groundwater extraction allocations

As we explained above, SGMA specifically allows a GSA to authorize temporary or permanent transfers of groundwater extraction allocations within its jurisdiction. Local groundwater markets under SGMA would be based on these transfers. In general, market transactions would likely involve the seller foregoing pumping all or part of their groundwater extraction allocation and the buyer exercising it instead by pumping and using groundwater in a different location. However, if parties have access to conveyance infrastructure, they could conceivably come to an agreement in which the seller pumps the water and physically delivers it to the buyer.

GSAs can learn from experiences with other groundwater-related markets and transfers, including existing groundwater markets, surface water transfers based on groundwater substitution, and markets involving banked groundwater.

2. Existing groundwater (and groundwater-related) markets

Markets involving groundwater transfers exist in a number of countries. Small-scale transfers of groundwater occur informally in many parts of the world. Informal markets generally rely on physical transfers of water across short distances from neighbors with wells to neighbors without wells. Formal markets have been documented in at least a handful of countries, most notably Australia,[74] and in a number of western U.S. states,[75] including in adjudicated areas of California (**Boxes 2, 4, and 5**).[76] **Appendix A** provides several international, U.S., and California examples to give a flavor for the variety present in these existing markets.

Transfers of pumping allocations are important components of some final judgments for California's adjudicated areas, including the Tehachapi Basin, Chino Basin, Mojave Basin Area, and Seaside Basin (**Table 2, Appendix A**). Similar concepts are used in other areas, such as the Edwards Aquifer in Texas, the Upper Republican Natural Resource District in Nebraska, and in Australia (**Appendix A**).

Surface water markets: Transfers based on groundwater substitution

One of the ways surface water can be made available for transfer in California is through groundwater substitution: when someone with surface water rights foregoes using them and pumps groundwater instead (**Appendix B**).[77] Groundwater substitution transfers that require SWRCB approval must be consistent with groundwater management plans adopted under state law or "[a]pproved by the water supplier from whose service area the water is to be transferred."[78]

Many surface water transfers, including transfers based on groundwater substitution, were executed through pooled "drought water banks" in the early 1990s.[79] This practice was controversial at the time,[80] and remains controversial today, especially in the Sacramento Valley.

Markets involving imported water deemed to have been stored underground

In California, imported water used to recharge an overdrafted groundwater basin as "part of a groundwater banking operation" can generally be transferred by the importer.[81] (**Parts III.C.2 and IV.B.1**)

C. Potential market impacts

GSAs in many groundwater basins, especially those identified as critically overdrafted, will need to limit pumping to address unsustainable groundwater use. Changing basin groundwater use patterns by reallocating limited groundwater resources among existing uses, and between existing and new uses, may help water users adapt to these limits.[82] A central argument advanced by market proponents is that markets enable the reallocation of limited resources at a lower cost than other mechanisms, including regulations alone.[83] However, changes in patterns of use can have negative, as well as positive, consequences. Therefore, GSAs need to think about how to effectively minimize the negative impacts and maximize the positive impacts of their management decisions, including implementing local groundwater markets.

Groundwater is a common-pool resource. Extractions by one user in one place affect the resource at large and, therefore, the ability of others to use the resource. Changing where or when groundwater is pumped or the place, method, timing, or purpose of its use can change the impacts experienced by people and ecosystems. The aquifers within a groundwater basin are not underground lakes, but zones of soil or rock that contain interconnected spaces through which groundwater can flow.[84] Physical, chemical, biological, and land use characteristics can vary substantially within the confines of a single aquifer system or groundwater basin.[85] Therefore, pumping or using groundwater at one place and time could have different effects on sustainability indicators associated with undesirable results (like seawater intrusion, subsidence, and surface water depletions) than pumping or using groundwater at another place or time. However, currently most groundwater basins lack "the proper institutional or incentive structures to ensure that groundwater extractions avoid third-party injuries."[86]

Negative impacts

A market does not operate in a void. Problems can result when individual and collective objectives are out of sync and market rules fail to address the disconnect.[87] "[T]he value of water extends beyond an individual's potential economic gains," and it can be difficult, if not impossible, to incorporate these other values into the price of a groundwater trade.[88] Used inappropriately, groundwater markets (like other management tools) can have significant negative externalities: harmful unintended or incidental effects on third parties or the environment that are not factored into or addressed in market transactions.[89]

One party's use of groundwater affects others. The location, amount, and timing of groundwater pumping and use can all affect the quantity or quality of groundwater available to others, how much it costs to extract, and whether subsidence occurs and damages infrastructure.[90] The undesirable results outlined in SGMA[91] (**Part II.A**) reflect a broad spectrum of the social and environmental externalities potentially associated with groundwater extraction and use.

Transfers that change the distribution of groundwater pumping and use could potentially increase the net amount of extraction occurring in some areas. This could have local impacts on the quantity or quality of water accessible to groundwater dependent ecosystems, low-income communities, and other individuals or constituencies (see **Part IV.C**). Transfers can also negatively impact the local economy in areas that experience reduced pumping; for example, farmworkers and agriculture-dependent communities may suffer job losses and other repercussions when transfers shift groundwater from agricultural to municipal use.[92]

These concerns are not just theoretical. Negative externalities have been documented or discussed in many market contexts, including groundwater markets.[93] For example, when groundwater trading first began in the North Adelaide Plains area of South Australia, trades ended up concentrating pumping in certain areas, severely drawing down local groundwater levels and necessitating the introduction of special trading rules to mitigate the problem.[94] Yet differences in the externalities related to pumping or using groundwater in different locations within a basin have not generally been incorporated into economic models of optimal groundwater extraction.[95]

Groundwater markets should not be blind to negative externalities, but should instead recognize and appropriately account for them.[96] **Appendix C** provides a window into how other environmental markets have tried to address trading externalities.

Positive impacts

Markets can be deliberately structured with the goal of minimizing the negative externalities of trades while maximizing their positive impacts.[97] Currently, there are places in basins where it would be especially desirable to reduce pumping, for example, areas of seawater intrusion and areas where groundwater provides critical baseflow for streams. Transfers of groundwater extraction allocations away from these areas can directly support progress toward sustainability goals. Trading rules like directional restrictions and trading ratios (**Part IV.D, Table 4**) could be used to maximize the potential benefits of groundwater markets, benefits which may be more politically difficult to achieve through regulations alone.

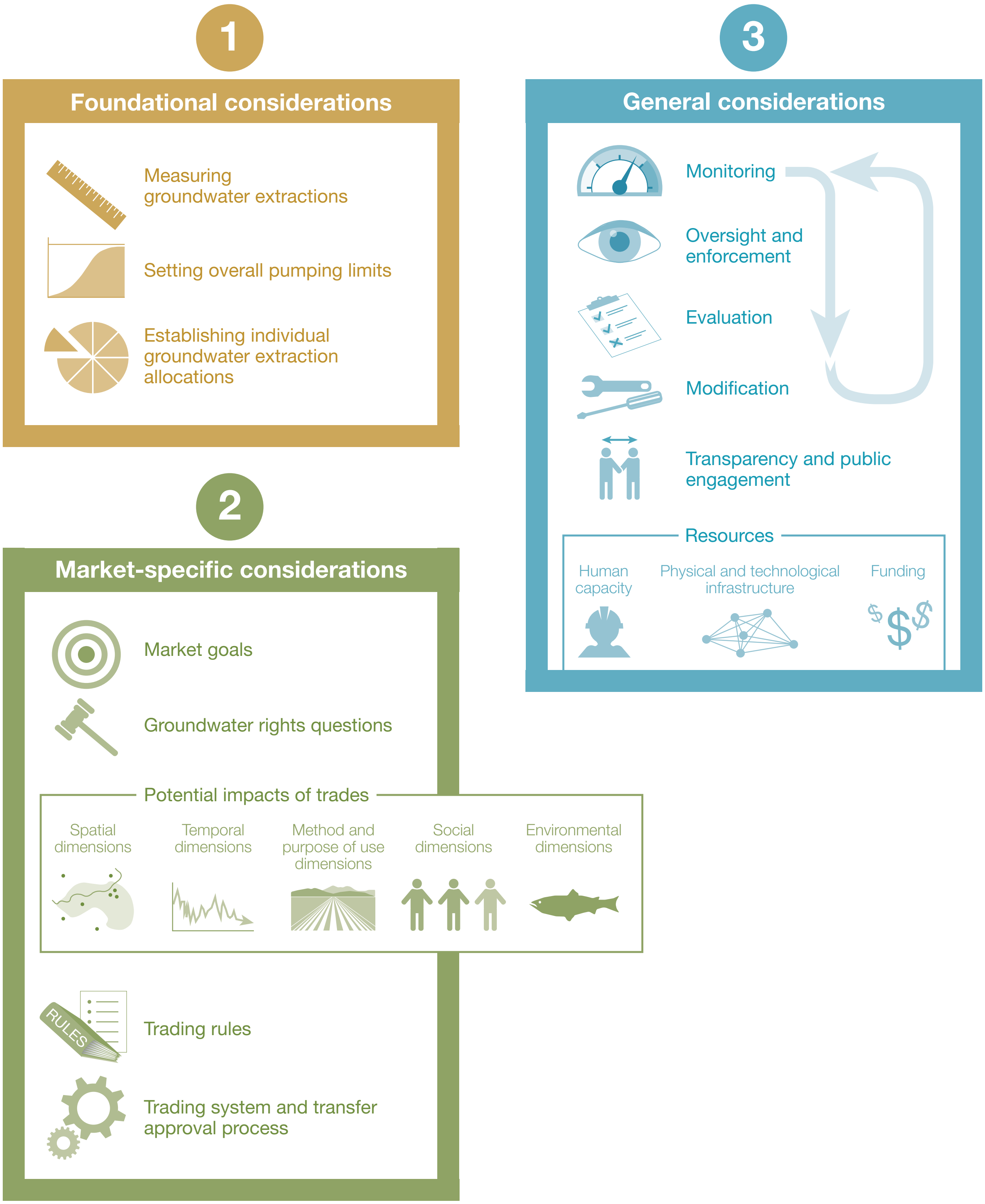
Critical considerations for local groundwater markets under SGMA

Information provides the foundation for good decision making. Before committing to specific management options available under SGMA, a crucial step for GSAs and the stakeholders they serve will be to carefully analyze potential management options and compare the expected benefits and burdens of each.

In theory, carefully designed and implemented local groundwater markets have the potential to enable socially, environmentally, and economically desirable redistribution of groundwater use that both helps basin water users adapt to pumping restrictions[98] established under SGMA and directly furthers SGMA's goals. However, this result is not a foregone conclusion. Instead, whether a local groundwater market might be a viable tool for furthering sustainable management in a particular basin will depend on a host of factors, including applicable laws and regulations, basin conditions (and the state of knowledge about basin conditions), market design, and market implementation.[99] Factors like local climate, geology, hydrology, ecological resources and needs, and social and economic conditions will all be important. In addition, GSAs will need to carefully consider how a local groundwater market would further local goals, including, but not limited to, sustainability goals. These factors may vary significantly from basin to basin, and even within a single basin. A local groundwater market may not be a viable management option where the potential impacts of trading are not well understood, where trading rules cannot sufficiently address negative externalities, or where—relative to other management options—the expected benefits of a market do not outweigh the burdens and uncertainties associated with designing and implementing it.

The remainder of this report is designed to help GSAs think about what they would need to do to adequately address trading externalities in their own basins. It outlines a set of considerations (**Figure 2**) designed to help GSAs and others evaluate whether a local groundwater market based on transfers of groundwater extraction allocations might be a viable management tool.

FIGURE 2. Overview of critical considerations for local groundwater markets under SGMA. These considerations are organized into three groups: (1) foundational considerations shared in common with other programs that limit groundwater pumping, (2) market-specific considerations, and (3) general considerations that are important for all groundwater sustainability programs. **Table 6** lays out these considerations in more detail.



III. Foundational considerations

Because local groundwater markets under SGMA would be based on transfers of groundwater extraction allocations, GSAs need to analyze a set of foundational considerations shared in common with other programs that include limits on groundwater pumping. These considerations relate to measuring groundwater extractions, setting overall pumping limits for basins and basin management areas, and establishing individual groundwater extraction allocations. These are steps that GSAs in many groundwater basins, including those identified as critically overdrafted, will likely need to take to address unsustainable groundwater use.

A. Measuring groundwater extractions

CONSIDERATIONS:

- What is known about historical groundwater extraction and use in the basin?
- How well understood are current patterns and volumes of groundwater extraction and use?
- How will groundwater extraction and use be measured going forward?

Information about past and present use provides essential context for setting overall pumping limits (including sustainable yield), establishing individual groundwater extraction allocations, and overseeing and enforcing both. In combination with other monitoring data, groundwater extraction and use information helps managers understand how pumping has affected basin conditions in the past and how changes in patterns and levels of pumping might affect basin conditions in the future. This is critical input for making management decisions.

Timely and accurate groundwater extraction information will also be necessary for local groundwater markets based on transfers of groundwater extraction allocations.[100] For markets to work, the parties to transfers will need to be able to understand and demonstrate what they are transferring, and GSAs will need to verify that transfers comply with groundwater extraction allocations, trading rules, and other requirements.

The amount of water pumped from the majority of wells around the state is not currently measured or reported.[101] For example, recent estimates suggest that approximately two-thirds of agricultural wells are unmetered.[102] However, pumpers in many adjudicated areas do measure their extractions. For example, the Mojave Basin Area adjudication requires everyone pumping more than 10 acre-feet of water per year to measure their extractions using meters, "flow measuring devices, electrical energy consumption records, time of usage records[,] or other methods having equivalent accuracy" and to file quarterly reports of production.[103] Some Special Act groundwater management agencies also require metering and reporting of groundwater extractions. For example, Fox Canyon Groundwater Management Agency requires flowmeters on all wells, except those "supplying a single-family dwelling on one acre or less" of land.[104] Additionally, since 1955, there has been a statutory requirement for people in four Southern California counties (Los Angeles, Riverside, San Bernardino, and Ventura Counties) who pump more than 25 acre-feet in a particular year to file a "notice" with the SWRCB that includes the quantity of groundwater extracted and other information.[105]

SGMA authorizes GSAs to adopt well-metering requirements. They can require pumpers, except those who extract 2 acre-feet or less per year for domestic purposes, to meter their wells and provide annual reports of their total extractions.[106]

KEY TAKEAWAYS

Information about past and present groundwater use provides essential context for setting overall pumping limits, for establishing individual groundwater extraction allocations, and for overseeing and enforcing both. In addition, proper accounting of groundwater extraction and use will be necessary for carrying out and confirming local groundwater market transactions.

B. Setting overall pumping limits

CONSIDERATIONS:

- How will the total amount of groundwater that may be pumped from the basin (and, if appropriate, from different management areas) be determined?
  - What sustainability indicators, minimum thresholds, measurable objectives, and interim milestones will be used to gauge undesirable results and progress toward sustainability?
  - How will these be translated into sustainable yield for the basin and, if appropriate, to extraction limits for different management areas?

SGMA allows GSAs to authorize transfers during a particular water year only if the total quantity of groundwater extracted in that time is consistent with a GSP designed to achieve sustainable management.[107] Therefore, a prerequisite for local groundwater markets under SGMA is figuring out what this means.

To sustainably manage groundwater, GSAs need to identify and limit cumulative extractions to the basin's sustainable yield. SGMA defines "sustainable yield" as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result."[108] Because it only has meaning with reference to undesirable results, estimating sustainable yield is a multi-step process that includes (1) identifying current or prospective undesirable results[109]; (2) establishing minimum thresholds[110] and measurable objectives[111] for related sustainability indicators[112]; and (3) determining what cumulative groundwater extraction limits—in other words, caps—will meet these objectives and eliminate or avoid the undesirable results.

This is not a trivial task. For example, each GSA must identify measurable objectives and interim milestones for sustainability indicators that will ensure the groundwater basin is operated within its sustainable yield within 20 years.[113] What does this entail? A 2015 report by the Union of Concerned Scientists concluded that developing and implementing effective measurable objectives for each sustainability indicator will require a GSA to:

- define clear baselines,
- set quantitative thresholds,
- develop protective triggers that require action before reaching a threshold,
- incorporate regular measurement and monitoring,
- account for uncertainty, and
- adapt to changing conditions and new information.[114]

Thresholds will need to be consistent with existing regulatory standards (e.g., for water quality), with thresholds developed for other undesirable results in the basin, and with thresholds in other hydrologically connected basins.[115]

To translate these into sustainable yield, the GSA will need to determine, likely with the help of one or more mathematical models,[116] what cumulative extraction levels will meet or exceed all minimum thresholds.[117] Any mathematical models will build on "a descriptive hydrogeologic conceptual model … that characterizes the physical components and interaction of the surface water and groundwater systems in the basin."[118] DWR has developed regulations that describe modeling requirements[119] as well as two documents describing modeling best management practices.[120] Other resources include a recent report by Stanford's Water in the West program, which offers a framework for developing mathematical groundwater models under SGMA and discusses various options.[121] While relatively simple analytical mathematical models may be appropriate for assessing some undesirable results or basins,[122] other undesirable results or basins may require complex numerical mathematical models—needing more data and greater technical expertise—to enable adequate understanding of basin groundwater systems, the variables that influence them, and the potential effects of different management options and changing basin conditions.[123] Measurement of groundwater extractions (**Part III.A**) and monitoring of basin conditions (**Part V.A**) will provide critical inputs for models and, ultimately, for a range of management decisions.[124]

Multiple pumping limits

For some basins, multiple limits on groundwater extraction may be useful or even necessary. If different parts of a basin are more or less likely to experience specific undesirable results, or to experience them more or less acutely, it may make sense to create distinct management areas[125] and to subdivide or allocate sustainable yield among these areas. Pumping limits for different management areas can work in conjunction with other mechanisms to promote transfers that yield sustainability benefits, for example, transfers that shift groundwater extraction away from sensitive areas and towards those areas less likely to experience specific undesirable results (**Part IV.D**).

Challenges

Determining sustainable yield will be challenging for many GSAs, which may not yet have all the information, human capacity, funding, and other resources they need.[126] Critical needs include an understanding of the hydrogeology and interconnectedness of aquifer systems; consumptive and non-consumptive surface water use and groundwater use; recharge; the impacts to third parties and the environment of historical groundwater extraction and use patterns; and the expected spatial and temporal variation of impacts under different future pumping scenarios.[127]

GSAs in data-poor areas may struggle on multiple fronts. For example, they may lack the information necessary to support basic water budgeting that describes the amounts and sources of water entering and leaving a basin and changes in water storage.[128] In its 2003 Update of Bulletin 118, DWR classified the groundwater budgets for many basins as either "estimated" or "little known."[129] Information has improved for some of these basins since then,[130] but for many, significant gaps and questions remain.[131] Furthermore, GSAs may have difficulty identifying appropriate sustainable management criteria or may lack sufficient information to understand the impacts of groundwater extraction and use. Indeed, a recent review of water accounting in California identified major gaps in understanding of groundwater availability, groundwater / surface water interactions, groundwater rights claims, and groundwater pumping and use.[132]

Even in areas where substantial information is available, it may be difficult to interpret or there may be disagreement about its interpretation.[133]

KEY TAKEAWAYS

SGMA requires GSAs to determine sustainable yield, "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." This value can serve as a limit on cumulative groundwater extractions. When basin conditions vary spatially, it may be useful to establish multiple management areas that are each apportioned part of the basin's sustainable yield.

C. Establishing individual groundwater extraction allocations

CONSIDERATIONS:

- What is the relationship between groundwater extraction allocations and common-law groundwater rights?
- How adversarial are basin stakeholders? How open to cooperative solutions are they?
- What factors will be used to determine individual groundwater extraction allocations?
- To what extent should differences in the characteristics of groundwater rights be accounted for in the allocation process? Under conditions of overdraft, will appropriative users still receive allocations? How will probable prescriptive uses be addressed?
- How will the allocation system address the dormant overlying rights of landowners not currently making overlying use of groundwater? How will it address landowners that want to begin new overlying uses in the future?
- What groups would benefit most, and least, from different allocation options?
- How should return flows to surface water or percolation to groundwater from the use of imported and native surface water be addressed?
- Will those issued allocations be able to carry over some or all of an unused portion for future use? If so, how much, for how long, and under what conditions?

Once a GSA determines the total amount of groundwater that may be sustainably pumped from a basin or basin management area per unit of time, the next step toward developing a local groundwater market is establishing individual allocations for each pumper. Although SGMA does not require a GSA to establish groundwater extraction allocations,[134] this is a necessary precursor for many demand-side management options. Steps in establishing allocations are likely to include identifying who should receive allocations, determining what information will be needed, collecting and evaluating the sufficiency of this information, developing one or more allocation methodologies, applying the allocation methodology(ies), and seeking feedback on the resulting allocations.[135]

In the abstract, many factors might play a role in groundwater extraction allocations. These include the amount of groundwater a party used historically, the proportion of land the party owns within the basin, and what the groundwater is used for.[136] An allocation could conceivably entitle the holder to a fixed quantity of water or to a share in the sustainable yield.

However, it is important to note that GSAs will not be starting with a blank slate. Instead, they will be establishing groundwater extraction allocations in a particular legal, social, and political context. GSAs need to give serious consideration to this context, including common-law groundwater rights, our focus here. Below, we summarize common-law groundwater rights, related rights to recover imported water and to use underground storage space, and California's constitutional requirement that all water use be reasonable and beneficial. We then look at different potential interpretations of the relationship between groundwater extraction allocations and common-law groundwater rights.

1. California groundwater rights

Although state statutory law has played a significant role in defining surface water rights (**Appendix B**),[137] rights to use groundwater have been almost wholly defined by common law. Courts have fleshed out groundwater rights in series of cases, some settling disagreements between a few parties[138] and some adjudicating the rights of all or the majority of groundwater users within a particular area (**Box 2**).[139] Case law describes five main types of rights to extract and use groundwater in California. This report focuses on the most common of these—overlying, appropriative, and prescriptive rights. **Box 3** briefly describes the other two: pueblo rights and federal reserved rights. This section also touches on two types of groundwater-related rights—rights to recover imported water and to use underground storage space.

Overlying rights

Overlying rights to use groundwater are tied to land ownership in a groundwater basin and are largely analogous to riparian rights (**Appendix B**) to use surface water.[140] Under a riparian right, the owner of land adjacent to a surface watercourse has the right to use its natural flow for reasonable beneficial use on that land.[141] Similarly, an owner of land overlying a groundwater basin has the right to extract a reasonable amount of native groundwater to support beneficial uses on that land.[142] Overlying rights are not lost through lack of use.[143] Instead non-pumpers are considered to have dormant overlying rights.[144]

Overlying rights are correlative. The amount of groundwater a landowner is entitled to put to overlying use is not quantified. Instead, it is an undefined and variable share of available groundwater flow that depends on actual basin conditions and competing uses.[145] During times of shortage, each overlying user is limited to that user's "proportionate fair share of the total amount available based upon his [or her] reasonable need."[146] This share is not predicated on past use during a specific period of time or assigned priority based on when the overlying use began; instead it depends on the landowner's "current reasonable and beneficial need for water."[147] Considerations for "determining each owner's proportionate share" in times of shortage potentially include "the amount of water available, the extent of ownership in the basin, [and] the nature of the projected use," among other things.[148]

Overlying uses have priority over appropriative uses during times of shortage, except to the extent an appropriator has gained a prescriptive right.[149]

Appropriative rights

Appropriative rights to use groundwater do not depend on land ownership but on the actual taking of groundwater. In California, appropriation is the "taking of water for other than riparian or overlying uses."[150] Since 1914, the appropriation of surface water has been administered by the SWRCB and subjected to permitting, licensing, and registration requirements.[151] Meanwhile, surplus groundwater—not needed for the reasonable beneficial uses of those with overlying rights—is available for appropriation, without a permit, for non-overlying use within the basin or for export.[152]

In aggregate, groundwater extractions may not exceed the basin's "safe yield,"[153] "the maximum that could be withdrawn without adverse effects on the basin's long term supply."[154] If extractions exceed this amount, the basin is considered to be in overdraft. Because overlying users have priority, appropriators must curtail their usage first during times of overdraft.[155] Unlike overlying rights, appropriative rights to use groundwater technically attach to a particular quantity of water and have differing priorities: "the one first in time is the first in right," so when not enough water is available for all, "a prior appropriator is entitled to all the water he needs, up to the amount that he has taken in the past, before a subsequent appropriator may take any."[156] However, the lack of permitting or recordation requirements means it can be much more difficult to determine the priority date and amount of an appropriative groundwater right than of an appropriative surface water right.[157]

BOX 2. The experiences of adjudicated areas offer useful insights for those considering local groundwater markets under SGMA, but differences in legal constraints may be important.

In most parts of California, groundwater users pump and use groundwater without having clearly defined or quantified their rights relative to other basin users. Notable exceptions exist in adjudicated areas.

An adjudication is a legal action brought to determine the water rights of multiple water users in part or all of a groundwater basin or watershed. Adjudications are often instigated by a small number of large water users.[158] Some address at least some aspects of both surface water and groundwater, but most involve only one or the other. Groundwater adjudications have been carried out in a number of areas around the state, most in southern California.[159] Commonly, key stakeholders negotiate an agreement, subject to approval or modification by a court, for allocating groundwater and managing the basin.[160]

Because most groundwater adjudications establish extraction allocations and allow them to be transferred, they offer potentially useful insights about how groundwater markets can work in practice. However, legal constraints in adjudicated areas can differ substantially from those in the unadjudicated areas of groundwater basins that are subject to SGMA. Therefore, GSAs should be wary of simply replicating the allocation and transfer systems they find in adjudicated areas. Instead, when reviewing the experiences of adjudicated areas, GSAs will want to keep the following points in mind:

- **SGMA exempts 29 listed adjudicated areas from its core requirements.** While these adjudicated areas only need to report information about area groundwater resources and use, GSAs must develop and implement GSPs to achieve sustainability.[161] (Note that SGMA does not exempt future adjudicated areas, and future adjudications should be consistent with sustainable groundwater management under SGMA.[162])
- **Adjudications have rarely addressed all the aspects of sustainable management identified in SGMA, although there has sometimes been significant overlap.**[163] Adjudications settle disagreements between parties about who should bear responsibility for solving particular problems.[164] They may not address the full range of sustainability issues that are relevant under SGMA. For example, according to a recent review, it is rare for adjudications to explicitly take environmental uses and impacts into account.[165]
- **In some areas, conditions worsened following adjudication.** For example, groundwater levels in parts of many adjudicated areas have declined since the adjudication occurred.[166] Potential causes could include inaccurate assumptions underlying management decisions (like safe yield calculations), inadequate oversight, and inadequate enforcement. GSAs will be responsible for avoiding undesirable results and could face state intervention if their plans and actions are not up to the task. Looking at how management under adjudications has actually affected basin conditions, and why, may be instructive.
- **Adjudications may not adequately consider some relevant stakeholders.** The areas covered by adjudications do not necessarily encompass entire groundwater basins,[167] and adjudications may not adequately address small groundwater users or disadvantaged communities.[168] The GSAs in a basin are collectively responsible for the sustainability of the entire basin, and they must consider the interests of a broad range of stakeholders.
- **Solutions developed through adjudications often involve importing water from outside the basin.**[169] Not all GSAs will have access to imported water, and, given California's natural climate variability and the changes expected to accompany ongoing climate change, the future reliability of imported water supplies could be an issue for adjudicated and unadjudicated areas alike.
- **Agreements that waive or alter rights, such as those reached in many adjudications, "are not helpful to understanding the rights … within existing legal frameworks."**[170] GSAs lack the power to determine or alter the relationships between water rights,[171] while adjudications routinely do both. This report raises questions about how this difference might impact how GSAs think about groundwater extraction allocations and their transferability (see **Parts III.C.4 and IV.B.2**).

Prescriptive rights

Prescriptive rights only come into play in basins that have experienced conditions of overdraft, and only have practical consequences during times of overdraft.[172] If an appropriator continues to pump when there is no available surplus, that taking of groundwater is wrongful, but it may "ripen into" a prescriptive right if certain conditions are met.[173] Specifically, the use must be "actual, open and notorious, hostile and adverse to the original owner, continuous and uninterrupted for the statutory period of five years, and under claim of right."[174] "Acquisition of a prescriptive right in groundwater rearranges water rights priorities among water users, elevating the right of the one acquiring it above that of an appropriator to a right equivalent in priority to that of a landowner."[175]

A prescriptive right is "quantified by determining the volume of water pumped during the prescriptive period and [is] limited to that amount."[176] California law bars the acquisition of prescriptive rights against public entities.[177] SGMA specifically prevents the use of groundwater pumping "between January 1, 2015," and the date a GSA adopts a GSP (or DWR approves an alternative) "as evidence of, or to establish or defend against, any claim of prescription."[178] In essence, this provision reduces incentives to "race to the pump" before GSAs have the chance to establish pumping limits or other programs to protect groundwater resources.

A number of cases suggest that overlying users can protect their interests from prescription not just by procuring a declaratory judgment but by continuing to pump during times of no surplus (termed "self help")[179] and that prescriptive rights cannot be determined relative to prospective overlying uses in a private adjudication.[180] However, the practical repercussions are not clear,[181] especially for overlying users in unadjudicated areas, since prescriptive rights are generally only recognized and confirmed through an adjudication or other litigation.

BOX 3. Less commonly encountered groundwater rights

Pueblo rights and federal reserved rights, although less commonly encountered, are critically important where present.

Pueblo rights

As municipal successors to Mexican pueblos, the cities of Los Angeles and San Diego have asserted rights to use as much of the waters of the streams that flow through them as is needed by the cities and their inhabitants.[182] Their pueblo rights apply to both surface streams and to hydrologically connected groundwater.[183] To the extent the municipal successor does not currently need this water, it remains accessible to others.[184] Where pueblo rights exist, they are paramount to overlying, riparian, and appropriative rights in the same waters.[185]

Federal reserved rights

In addition to overlying, appropriative, and prescriptive rights,[186] the federal government can hold federal reserved rights in water. These rights arise when the federal government reserves land from the public domain for federal purposes, like an Indian reservation, a national monument, or a national park. The U.S. Supreme Court has held that federal reservations implicitly reserve "water rights sufficient to accomplish the purposes of the reservation."[187] Although federal reserved rights "are not dependent upon state law or state procedures,"[188] they are "subject to whatever rights may have vested while the lands were in the public domain."[189] The specific federal purposes they support may find additional protection as Public Trust uses.[190]

The extent to which federal reserved rights apply to groundwater has been unclear. In 1976, the U.S. Supreme Court held that the United States could protect its reserved rights in surface water from injury by later diversions of surface water or groundwater.[191] Recently, in March 2017, the Ninth Circuit concluded that the reserved rights doctrine also applies directly to groundwater.[192] It held that the Agua Caliente Band of Cahuilla Indians in California's Coachella Valley "has a reserved right to groundwater underlying its reservation as a result of the purpose for which the reservation was established"—"to create a home for the Tribe"—leaving quantification of that right for a future phase of the litigation.[193]

2. Rights to recover imported water and to use underground storage space

In addition to the rights to extract and use groundwater summarized above, other groundwater-related rights will play a key role in many of California's groundwater basins. These include rights to recover imported water and rights to use underground storage space.

Rights to recover imported water

Storing water in an aquifer system is legally similar to storing water in a surface reservoir.[194] This is a type of conjunctive use and a major factor in groundwater banking.[195] When a particular party imports water from outside a groundwater basin and either directly or indirectly recharges the aquifer, that party generally maintains the right to recover the water later. This right extends to return flows (water not consumptively used in a given application, like irrigation) and, if excess storage capacity is available, to water deliberately placed in underground storage through spreading or other means.[196] Storage can also be accomplished indirectly, by using imported water in lieu of pumping water under a groundwater right.[197]

Rights to use underground storage space

The California Court of Appeal has held that groundwater "[e]xtraction and storage are different physical processes" and that "establishing a hydrologic link between them is not sufficient to show that a legal interest in one creates an interest in the other."[198] Underground storage space could conceivably be allocated in different ways.

The interests of those who use underground storage space may come into conflict with the interests of users of native groundwater, including groundwater dependent ecosystems.[199] For accounting purposes, when imported water is banked, it takes up storage space within the aquifer system. Similar accounting applies when unused portions of groundwater extraction allocations are allowed to be carried over from one year to the next (**Part IV.C.2**). Both decrease the remaining storage capacity available for recharge that is considered part of the basin's safe yield. In some basins, there may be adequate unused storage capacity to accommodate these storage uses, which—if governed by appropriate rules—could have largely positive externalities (e.g., raising groundwater levels which could potentially reduce pumping costs, improve groundwater quality, and help to maintain important groundwater / surface water connections). However, in other basins, such as those with little unused storage capacity or rapid flow-through, storage rights and related withdrawals based on incorrect water accounting assumptions could have significant negative unintended consequences.[200] As a result, it is important for GSAs to think through the consequences of different possibilities for allocating storage in their basins.[201]

Parties to adjudications have arrived at various arrangements for allocating the use of underground storage space. The Six Basins Area adjudication provides one example of how storage rights have been managed. Parties to the adjudication agreed that rights to storage capacity in part of the Area (the Four Basins Area) belonged to the 9 parties holding Base Annual Production Rights there and to a 10th entity, a municipal water district.[202] The stipulation provided that, when unused storage capacity is available, its use will be prioritized as follows: (1) storage of "replenishment water" (native water that "comprises a portion of the Operating Safe Yield pursuant to a historical replenishment program"), (2) storage of carryover rights, (3) storage and recovery of native water, (4) storage and recovery of imported water, and (5) storage and recovery of other water.[203] Parties can lose all or some fraction of their unpumped storage and recovery rights in the event there is insufficient storage capacity for replenishment water.[204] Similarly, the Antelope Valley area adjudication allows parties to enter into storage agreements with the watermaster but specifically bars them from allowing "operations, including the rate and amount of extraction, which will cause a Material Injury to another Producer or Party, any subarea[,] or the Basin."[205]

3. The constitutional requirement for reasonable and beneficial water use

All water rights are limited to the amount that is reasonably and beneficially used.[206]

Reasonable use

There is no right to an unreasonable use of water.[207] The California Supreme Court first applied the reasonable use doctrine to groundwater in 1903.[208] Since 1928, the California Constitution has explicitly barred "the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water" and required that "conservation … be exercised … in the interest of the people and for the public welfare."[209] What is considered reasonable necessarily changes with time and circumstances, so past levels of use are not conclusive evidence of reasonableness.[210]

In the groundwater context, SGMA helps define reasonable use. In passing the Act, the California legislature codified the principle, initially developed through case law, that using groundwater in excess of a basin's sustainable yield is unreasonable.[211] By identifying sustainability indicators, undesirable results, measurable objectives, interim milestones, and minimum thresholds, GSAs will also weigh in on what they think is reasonable—but they will not have the last word. In exercising oversight, DWR and the SWRCB may come to different conclusions than particular GSAs (see **Box 8**).

Beneficial use

The same provision of the California Constitution states that "the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable."[212] Case law, state statutes, and regulations have all helped to define which purposes of use are beneficial: these include municipal use, industrial use, irrigation, support of fish and wildlife, protection of water quality, and many others.[213] California law prioritizes domestic uses[214] and recognizes a human right to "safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" (**Box 7**).

Storage of water underground, in and of itself, is not considered a beneficial use. Instead, those who store water, whether in a reservoir or in available underground storage space, must do so with a subsequent beneficial use in mind.[215] For recharge, this could be repelling seawater intrusion, supporting fish and wildlife, or later agricultural or municipal use. Notably, in 1992, the California legislature established a state policy of encouraging the conjunctive use of groundwater and surface water.[216] In support of conjunctive use, the California Water Code treats "the use of water from an alternate nontributary source" in lieu of pumping groundwater to permit replenishment as "a reasonable beneficial use of the groundwater" if the user files an annual statement with the SWRCB.[217] Many adjudications also encourage conjunctive use.

4. Groundwater rights and groundwater extraction allocations

In the absence of systematic oversight, the legal limits of California groundwater rights have been enforced through infrequent, and generally expensive, litigation. Lack of oversight contributed to the overexploitation of groundwater resources that spurred SGMA's enactment,[218] and SGMA implementation efforts are likely to focus new attention on groundwater rights issues. This is especially true where a GSA intends to restrict pumping by establishing groundwater extraction allocations, whether or not it plans to take the additional step of authorizing transfers.

What is the relationship between groundwater rights and groundwater extraction allocations developed under SGMA?

SGMA clearly envisions GSAs being able to establish groundwater extraction allocations as a tool to limit pumping.[219] However, it does not specify how reductions in groundwater pumping should be allocated among the groundwater users in a basin, and the legal relationship between groundwater extraction allocations and common-law groundwater rights is not entirely clear. Should the characteristics of a particular groundwater right constrain the characteristics of the related groundwater extraction allocation or not? Because case law does not directly address this issue, analyzing it necessarily involves extrapolation and uncertainty. Below we discuss two potential interpretations.

Interpretation 1: Groundwater extraction allocations are constrained by existing groundwater rights

SGMA explicitly states that it does not determine or change water rights or priorities.[220] What does this imply about the relationship between groundwater rights and groundwater extraction allocation developed under SGMA? One potential interpretation is that groundwater extraction allocations need to reflect the limitations inherent in different types of groundwater rights. In this view, GSAs can impose allocations that acknowledge these limitations and further restrict groundwater use consistent with the constitutional requirement for reasonable beneficial use.

In the context of adjudications, California's highest court has concluded that courts cannot impose allocations that ignore the characteristics of existing groundwater rights. In its 2000 decision in *City of Barstow v. Mojave Water Agency* (knows as the Mojave Basin Area adjudication), the California Supreme Court held that adjudication decisions that "d[o] not attempt to determine the priority of water rights, and merely allocate[] pumping rights based on prior production," improperly "elevate[] the rights of appropriators and those producing without any claim of right to the same status as the rights of riparians and overlying owners."[221] The court acknowledged that parties to an adjudication may freely stipulate to different treatment of their rights (**Boxes 2, 4, and 5, Table 2**).[222] For example, they could stipulate to an agreement that assigns groundwater extraction allocations in a way that is inconsistent with the characteristics and constraints of their existing groundwater rights, such as based solely on the amount of past use, without regard to whether the use was overlying or appropriative. However, a court may not simply ignore the existing groundwater rights of non-stipulating parties. It cannot apply equitable apportionment to these parties unless it first determines what their rights are and concludes that following priority would be inconsistent with reasonable use, for example when all parties have been relying on basin groundwater for a long time and have established "mutual prescription."[223]

It is reasonable to think that groundwater extraction allocations developed by GSAs, like those imposed by courts, would remain subject to the constraints of related groundwater rights.[224] Whereas a regulatory agency can establish a new system of pollution allowances without fear of interfering with preexisting rights to pollute (there are no such rights), a GSA does not start with a similarly clean slate. As a consequence, establishing a secondary system of water use entitlements (i.e., groundwater extraction allocations under SGMA) that effectively ignores or displaces the preexisting system of common-law groundwater use rights could be legally and politically risky.

Recall that an overlying right attaches to the user's "proportionate fair share" of the total amount of groundwater available based on the user's "reasonable need."[225] Meanwhile, an appropriative right can technically only be exercised when there is surplus groundwater available under the user's particular priority of appropriative right. Without all right holders' agreement, simply assigning allocations to appropriators and overlyers alike in proportion to their past use, regardless of conditions of surplus or overdraft, would not seem to be consistent with the limitations of related groundwater rights. On the other hand, attempting to adhere strictly to groundwater right priorities, when those rights have not yet been determined through an adjudication, could also be problematic. As explained above, overlying rights are correlative and not associated with a particular quantity of water, and claims of prescriptive right may be unclear.

GSAs might be able to create different types of allocations that correspond to different types of rights.[226] For example, a GSA might provide appropriative users with allocations only during years when surplus water would have been available under their priority of right; when the basin is in overdraft, they would receive no allocations. However, this could have draconian consequences, like cutting off all pumping by cities who supply water to their residents (considered an appropriative use) during times of overdraft, and would likely run afoul of the constitutional requirement for reasonable use, the priority for domestic beneficial uses, and the Human Right to Water. Taking these into account, a GSA might design a less harsh option that does not deprive people of water needed for consumption and sanitation by assigning appropriators a full share during times of surplus and a reduced allocation sufficient to cover minimum human health and safety needs during times of overdraft[227] Alternatively, a GSA might decide to, for example, provide both overlyers and appropriators with allocations every year, basing the overlyers' shares of sustainable yield on their maximum use during a specific baseline period and appropriators' shares on a fraction of their maximum baseline use, reflecting the probability that surplus water would be available under their priority of right on average.

In sum, under this interpretation, groundwater extraction allocations are constrained by existing groundwater rights and other applicable law, including the constitutional requirement for reasonable and beneficial use. A GSA's allocation decisions might conceivably reflect these constraints in various ways.

Interpretation 2: Groundwater extraction allocations are not constrained by existing groundwater rights

Some suggest that, because they are not themselves groundwater rights, groundwater extraction allocations do not need to be consistent with groundwater rights. In this view, ownership of a groundwater right would be a precondition for receiving an allocation, but the characteristics of that right need not affect the characteristics of the allocation.[228] GSAs might be able to come up with allocation regimes that do not closely track groundwater rights but that basin stakeholders nonetheless think are fair and reasonable, for example, assigning each user a share in sustainable yield based on the volume of their past use.[229]

Because many users do not currently measure how much groundwater they pump, many allocation methods would require users who had not previously measured their extractions to develop acceptable estimates of past use and to measure their extractions going forward.

Questions...

As GSAs begin to get down to the nitty-gritty business of crafting plans and programs to achieve sustainable groundwater management in their basins, what allocations can or should look like will become an increasingly important topic of discussion. Potential allocation-related questions include the following:

- What is the relationship between groundwater extraction allocations and common-law groundwater rights?
- How adversarial are basin stakeholders? How open to cooperative solutions are they?
- What factors will be used to determine individual groundwater extraction allocations?
- To what extent should differences in the characteristics of groundwater rights be accounted for in the allocation process? Under conditions of overdraft, will appropriative users still receive allocations? How will probable prescriptive uses be addressed?
- How will the allocation system address the dormant overlying rights of landowners not currently making overlying use of groundwater? How will it address landowners that want to begin new overlying uses in the future?
- What groups would benefit most, and least, from different allocation options?
- How should return flows to surface water or percolation to groundwater from the use of imported and native surface water be addressed?
- Will those issued allocations be able to carry over some or all of an unused portion for future use? If so, how much, for how long, and under what conditions? (**Part IV.C.2**)

Some adjudications provide potentially useful examples of attempts to address these types of questions. Recognizing the differences in legal context will be important, however. Early adjudications, especially, often treated overlying and appropriative rights essentially the same for the purposes of allocation[230] (**Boxes 2, 4, and 5, Table 2**).

To help resolve current legal ambiguities, GSAs and their stakeholders could ask the legislature to clarify the relationship between groundwater extraction allocations and related groundwater rights.

Stakeholder engagement

Robust stakeholder engagement in developing groundwater extraction allocations will be critical. Whether or not a local groundwater market is on a GSA's horizon, given the ambiguity surrounding the relationship between groundwater extraction allocations and related groundwater rights, GSAs would be wise to rely on robust stakeholder engagement processes in developing them (**Part V.E**). This will be especially critical for GSAs thinking about establishing extraction allocations that depart from strict interpretations of groundwater rights.

Beyond the fact that SGMA requires public engagement at all stages of GSP development and implementation, earning stakeholder buy-in can be helpful in a range of ways. Knowledge of how adversarial or open to cooperative solutions basin stakeholders are can inform a GSA's approach to allocation outreach and engagement and help it identify potential allocation alternatives. If individual groundwater users see themselves as not being heard and losing out in the allocation process, they might try to pursue water right takings claims or initiate an adjudication. Robust, meaningful engagement can increase voluntary compliance and reduce the likelihood of conflict. The risk of unhappy stakeholders (and adverse legal actions) will decrease if a GSA selects methods for allocating extractions through an inclusive, intensive, and well-documented stakeholder process that fosters broad stakeholder agreement. While this will require more time up front, once completed, the chosen allocation methodology can be implemented more quickly, with less potential for resistance. Furthermore, if a stakeholder later decides to challenge the allocations by initiating an adjudication, a thorough participatory process could potentially enable a relatively quick adjudication process.[231]

Some GSAs may conclude that proactively pursuing a statutory adjudication that determines groundwater rights and establishes extraction allocations would be a worthwhile step towards creating a local groundwater market that furthers sustainable management.

KEY TAKEAWAYS

Because the relationship between groundwater extraction allocations and groundwater rights is not clear, GSAs should develop groundwater extraction allocations through robust stakeholder engagement processes that foster stakeholder buy-in. This will reduce the likelihood that unhappy basin water users pursue water right takings claims or initiate an adjudication. If an adjudication is triggered, a robust stakeholder engagement process will likely reduce the burden of adjudication. Some GSAs may conclude that pursuing a statutory adjudication that determines groundwater rights and sets extraction allocations would be a worthwhile, clarifying step in creating local groundwater markets that further sustainable management.

BOX 4. Extraction limits and allocations in California's adjudicated areas

The 29 listed adjudicated areas exempted from SGMA's core requirements face different legal constraints than do unadjudicated areas subject to SGMA (see **Box 2**). Therefore, while the extraction limits and allocations developed through adjudications offer potentially useful lessons for GSAs looking to develop their own, it is important to examine them with a critical eye.

Extraction limits in adjudicated areas

The limits on groundwater extraction and use defined through an adjudication are not necessarily the equivalent of "sustainable yield" under SGMA (**Box 2, Table 2**). Most adjudications have established one or more limits, generally described as "safe yield," on groundwater extractions in all or part of the adjudicated area. The limits usually have some hydrogeologic basis, and are often adapted over time as conditions change, but in some cases they appear to be predominantly keyed to aggregate past use.

Allocations in adjudicated areas

In an adjudication, groundwater users can "agree to a judgment which waives or alters their water rights in a manner which they believe to be in their best interest." [232] This freedom to "waive or alter" water rights by consent means that some of the allocation methods used in past adjudications are potentially inconsistent with strict interpretations of unadjudicated groundwater rights.

Although the details vary from adjudication to adjudication (see **Table 2**), in general, allocations have been determined in at least two steps:

1. **Designate each groundwater user's share of aggregate groundwater extraction** — This has usually been based on historical use, for example, the user's largest annual extraction during the 5 years prior to initiation of the adjudication. To calculate the user's proportional share, this amount is divided by the aggregate value for all groundwater users. A few adjudications have treated allocations differently based in part on the end use of the water (e.g., agricultural, industrial, municipal).
2. **Calculate each groundwater user's extraction allocation for a designated future time period** — This has generally involved multiplying the extraction limit (e.g., annual or seasonal safe yield) by the user's designated share.

Some adjudications have treated those with overlying rights and those with appropriative or prescriptive rights essentially the same for the purposes of allocation. However, most adjudications after 1977 have given some kind of priority to overlying rights relative to appropriative rights, or have at least recognized the unchanged overlying rights of non-stipulating parties. A recent review of California groundwater adjudications commissioned by the SWRCB suggested that, under adjudications, "overlyers are often allowed to pump with only limited restrictions, generally do not have to reduce pumping until appropriators reduce their withdrawals, and sometimes do not have to reduce pumping at all."[233]

Carry over of unused allocations in adjudicated areas

In some adjudicated areas, unused allocations can be carried over indefinitely (e.g., in parts of the Upper Los Angeles River Area[234]), while in others carry over is time-limited[235] or restricted to a fraction of the full allocation or the unused portion (e.g., in the Six Basins area[236]).

Foreclosure of dormant rights

Some adjudications foreclose dormant overlying rights (e.g., in the Chino Basin, **Table 2**).

TABLE 2. Examples of overall extraction limits, allocations, and transfer rules in California's adjudicated areas. Some adjudications have treated those with overlying and appropriative rights largely the same (not differentiated), while others have assigned them different rights and responsibilities (differentiated).

Area	Overall limits	Allocations	Transfers	Differentiation
Tehachapi Basin[237] (1971)	Two-thirds of aggregate Base Water Rights	**Base Water Right** Highest continuous extraction after overdraft started (except each domestic well is assigned 3 acre-feet/year) **Allowed Pumping Allocation** Two-thirds of Base Water Right **Carry over:** 2 years, up to 25% of Allowed Pumping Allocation	Of Base Water Rights or Allowed Pumping Allocations (except for domestic wells) **Export:** No export from Basin	Not differentiated (except for domestic wells)
Chino Basin[238] (1978)	**Adjudicated Safe Yield** 140,000 acre-feet/year **Operating Safe Yield** Appropriative Pool's share of Safe Yield + authorized Controlled Overdraft	**Pool 1:** Overlying Agricultural Pool Rights = Correlative share of 82,800 acre-feet/year **Pool 2:** Overlying Non-Agricultural Pool Rights (industrial or commercial users) = Decreed shares of Safe Yield **Pool 3:** Appropriative Pool Rights (municipal users) = Decreed shares of Operating Safe Yield **Carry over:** Pool 2 or 3; May require storage agreement	Within Pool 2; Within Pool 3; From Pool 2 to watermaster or, via watermaster, to Pool 3, if Pool 2 uses recycled water instead Pool 3 may "exercise" Pool 2's rights "to the extent necessary to provide water service to said overlying lands" Pool 1's unused allocations are reallocated to Pool 3 **Export:** Replenishment costs for exports increased post-1976	Differentiated by pool Un-exercised overlying rights considered "lost" by prescription
Mojave Basin Area[239] (1996)	For each of 5 hydrologic subareas: **Production Safe Yield** Initially 100% of the subarea's aggregate Base Annual Production, reduced to 80% over 4 years, with later adjustments based on conditions	**Base Annual Production Right** % of aggregate Base Annual Production (based on the maximum annual production during a year from 1986–1990) **Free Production Allowance** Base Annual Production Right x subarea Production Safe Yield **Carry over:** 1 year	Of Base Annual Production Rights, Free Production Allowances, Carryover Rights *Between subareas:* Authorized leases only; Cumulatively limited to the source subarea's replacement water requirement for prior year; Replacement obligation incurred for water pumped then transported to another subarea Amounts adjusted to avoid increasing consumptive use **Export:** No export from Basin Area without court approval	Physical solution does not apply to those producing less than 10 acre-feet/year Non-stipulating overlyers maintain their rights
Seaside Basin[240] (2006)	For each of 2 subareas: **Operating Safe Yield** Initially based on historical usage, then reduced 10% every 3 years to reach Natural Safe Yield	**Base water right** Assigned % or fixed amount **Standard Production Allocation** Share of subarea Operating Safe Yield **Alternative Production Allocation** = Prior and paramount right to specified volume of water **Carry over:** Standard Production Allocations only; Up to available Storage Allocation; Potentially subject to reduction	Of Standard Production Allocations, Carryover Credits Some limits on transfers between subareas **Export:** No export from Basin	Overlyer's choice of Standard or Alternative Production Allocation Does not govern those producing less than 5 acre-feet/year

IV. Market-specific considerations

A number of additional considerations are relevant for local groundwater markets based on transfers of groundwater extraction allocations. These considerations relate to market goals, groundwater rights questions, and the potential impacts of trading. Carefully designed trading rules will be needed to ensure that trades support progress toward sustainability and sufficiently address negative impacts to third parties and the environment. GSAs will also need to consider how to structure the trading system and transfer approval process to enable buyers and sellers to find one another and to operationalize trading rules and other requirements.

A. Market goals

CONSIDERATIONS:

- What is the market intended to accomplish (or avoid)?
- How will the market complement or reinforce other sustainability programs?
- How will market success be measured?

A market is not an end in itself, but a means of achieving particular ends, and it should be tailored to meet those ends.[241] Local groundwater markets developed under SGMA need to have clearly articulated goals that are consistent with SGMA and other applicable legal requirements. Without them, there is no yardstick for success. Progress cannot be tracked, and adaptive management is impossible. Therefore, a GSA should be prepared to define what it intends a transfer program to accomplish and how the program complements or reinforces other aspects of the GSA's sustainability program.[242] For example, through a local groundwater market, a GSA might seek to enable groundwater users to voluntarily redistribute the basin's sustainable yield among themselves in a way that maximizes the sustainability gains from trading by shifting pumping away from problem areas. The program would be considered effective if it achieves these goals and ineffective if it does not.

KEY TAKEAWAYS

Groundwater markets under SGMA need explicit goals that are consistent with sustainable management.

B. Groundwater rights questions

CONSIDERATIONS:

- To what extent should the characteristics of common-law groundwater rights affect the transferability of groundwater extraction allocations?
- How might transfers of groundwater extraction allocations injure other water users?

As **Part III.C.4** explained, the relationship between groundwater extraction allocations and groundwater rights under SGMA is not clear. Do allocations need to respect key differences in the characteristics and constraints of related groundwater rights, or are allocations part of a regulatory overlay that need not reflect these differences? Here we examine groundwater rights issues that become important for markets if there is a tight linkage between groundwater rights and groundwater extraction allocations.

1. Groundwater rights and property right characteristics important for markets

In general, a clear legal framework that allows the transfer of groundwater rights or related extraction allocations would be a precondition for a successful local groundwater market.[243] One challenge GSAs will face is that the California case law that defines who may pump and use groundwater, how much, and under what circumstances does not readily fit this description. Because SGMA does not determine or change water rights, a GSA's management actions—including authorizing groundwater transfers—might reasonably be considered to be subject to their constraints. The essential issue is that a party cannot legally transfer a right it does not have.

Economic theory describes basic characteristics of property rights that affect market efficiency. These can be summarized as exclusivity, divisibility, transferability, and enforceability (**Table 3**).

The property rights relevant for environmental markets will rarely be completely exclusive, infinitely divisible, transferable without restriction, or always straightforward to enforce. Instead, they will fall somewhere on a spectrum for each. Additionally, these characteristics often have fuzzy boundaries when translated into actual property rights contexts. Nevertheless, a restriction in any of these dimensions could potentially reduce market efficiency.

Groundwater is a common-pool resource.[244] Extractions by one user in one place affect the resource at large and, therefore, the ability of others to use the resource. The impacts of groundwater transfers may extend far beyond the parties involved in individual transactions (**Parts II.C and IV.C**). These features suggest that groundwater rights, overall, have relatively low exclusivity.[245] However, there are important distinctions among different types of rights for this and other characteristics. These are summarized in **Figure 3** and discussed in more detail below.

TABLE 3. Basic characteristics of property rights that affect market efficiency.[246]

Characteristic	Considerations
Exclusivity	To what extent can the right holder exercise the right without interference from others? To what extent will the benefits and burdens of the right, and of transferring the right, accrue to the parties to the transfer? To other parties?
Divisibility	To what extent is the right to use the resource able to be divided among users? To what extent can the right be separated into smaller physical, temporal, or legal units?
Transferability	To what extent can the right holder physically and legally sell, trade, or lease a right or some aspect of it?
Enforceability	To what extent do social or legal structures defend the right from infringement or involuntary seizure and ensure that it is exercised appropriately?

Characteristics of overlying rights

An overlying landowner has the right to extract a reasonable amount of groundwater, in light of the demands of other overlying users, to support beneficial use on his or her land within the basin. By definition, then, overlying rights are not fixed in quantity and have low exclusivity relative to other overlying rights but are collectively intended to be exclusive of appropriative rights during times of shortage. Absent quantification through an adjudication, an overlying right would not appear to be divisible (how does one subdivide an unquantified amount?).

Case law suggests that an overlying right can generally only be transferred by selling or leasing the land to which it is linked, but that overlyers may be able make alternative arrangements to serve their properties with groundwater:

- **Use on another of the landowner's parcels** — Courts do not appear to have directly addressed whether water pumped under an overlying right must be used on the particular parcel it is pumped from, or whether it can be used on other land owned by the landowner in the same basin.[247] However, the California Supreme Court has suggested in dicta that an overlying user who owns several parcels in a basin could potentially pump and distribute groundwater from one parcel for overlying use on all the parcels.[248]
- **"Substitution"** — Water pumped and physically conveyed to another landowner in the basin for use on that person's land would generally not be considered put to overlying use.[249] For example, where a municipality or water company extracts groundwater from a basin it overlies and sells the water to customers whose land also overlies that basin, the use is considered an appropriative public use, not an overlying use.[250] However, the California Supreme Court has suggested in dictum that a municipality could become "substituted" for an overlying landowner if it acquired the landowner's rights "only for use on the particular land of such owner."[251] Indeed, California courts have concluded that mutual water companies[252] can do just that.[253] It would presumably also be acceptable for neighboring overlying landowners to access groundwater from a single well on one owner's land.

Given their characteristics and constraints, transfers of overlying rights as part of a groundwater market would probably not be feasible without an adjudication that quantifies them and alters their constraints. Enforcement may also be challenging.

Characteristics of appropriative rights

In theory, appropriative groundwater rights attach to a particular amount of water and are exclusive of one another, such that a junior appropriator is only entitled to pump groundwater if more senior appropriators are able to satisfy their rights from the available surplus. In practice, however, appropriative rights have generally only been quantified in some adjudicated basins. In unadjudicated areas, some appropriative users may not measure their extractions. On the other hand, others—like municipalities, public water utilities, and private water companies—may have extensive historical data to support their claims of right.

Because appropriative rights are not tied to use on specific land, they could potentially be transferred to others for use within or (without other constraints) outside the basin. Since an appropriative right is associated with a particular amount of water, it could theoretically be divided up into smaller units, allowing an appropriator to transfer all, or some fraction of, the right. These features also potentially enhance the enforceability of appropriative rights relative to overlying rights.

However, surplus water capable of supporting some or all appropriative rights might be available only infrequently or not at all in some basins subject to SGMA, especially those subject to critical conditions of overdraft.

Characteristics of prescriptive rights

The characteristics of prescriptive rights in an unadjudicated area are still more unclear. Especially in basins that are not continuously experiencing conditions of overdraft, there may be questions about whether the elements of prescription have been satisfied[254] and, if so, to what quantity of groundwater the prescriptive user is entitled.

Once acquired, during times of surplus, prescriptive rights effectively function as appropriative rights and so share their characteristics. However, the properties of even recognized prescriptive rights are not entirely clear during times of overdraft.[255] To the extent prescriptive rights are considered to have invaded overlying rights (by preventing overlying users from accessing all the groundwater they would otherwise have put to reasonable, beneficial use), during times of overdraft, they might also be considered exclusive of overlying rights. On the other hand, where overlyers have been able to keep pumping all they needed in times of overdraft, overlyers and prescriptors alike might need to share in the shortage. In this case, some of the characteristics of prescriptive rights might be more similar to those of overlying rights.

Characteristics of rights to recover imported water

Rights to recover imported water appear to be the most straightforward to map onto the basic characteristics of property rights. The party that imports water from outside a groundwater basin maintains the right to recover related return flows and, if excess storage capacity is available, water deliberately placed in groundwater storage through spreading or other means.[256] These rights are likely to be the most exclusive, most easily divisible, most clearly transferable, and, since they are most likely to be accompanied by documentation, the easiest to enforce.

2. Groundwater rights and transferability rules

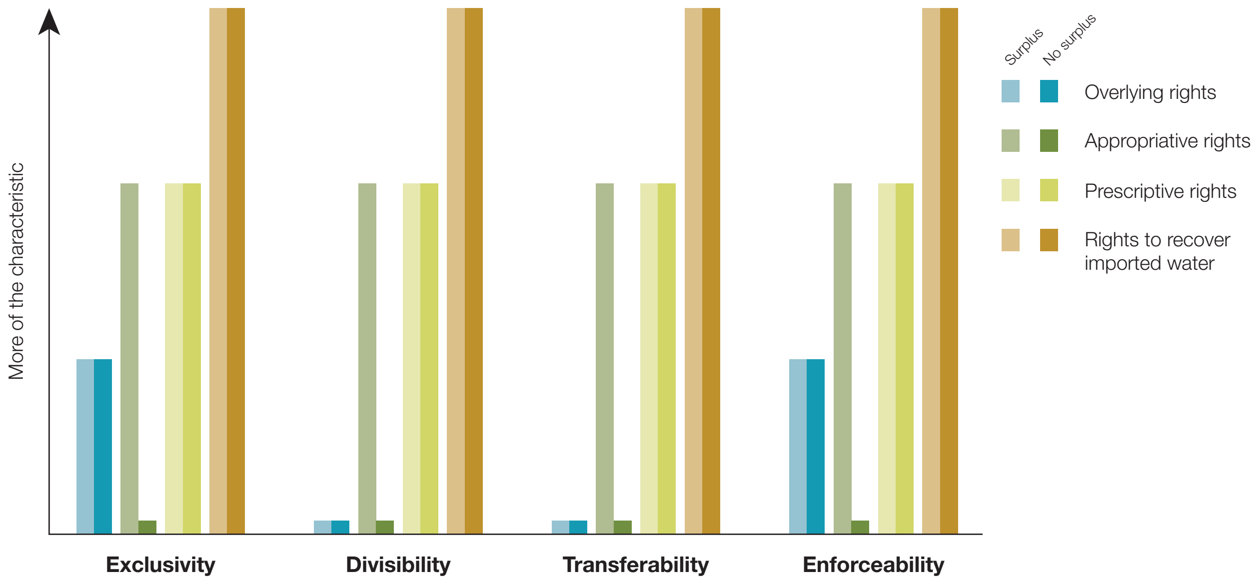
As we noted in **Part III.C.4**, GSAs should consider the relationship between groundwater extraction allocations and groundwater rights. They should ask whether and how differences in the characteristics of groundwater rights should be accounted for in the allocation process and whether and how these differences should affect transferability. Regardless of the answers GSAs arrive at, robust stakeholder engagement may help the agencies navigate these issues successfully, while failing to address them adequately could prompt an adjudication or lay the groundwork for water right takings claims.

Again, we examine two potential interpretations of the relationship between groundwater extraction allocations and related groundwater rights.

Interpretation 1: The transferability of groundwater extraction allocations is constrained by the characteristics of existing groundwater rights

As **Part III.C.4** suggests, GSAs could potentially create different types of allocations that correspond to different types of rights. They might also assign each type of allocation “different opportunities.”[257] Because appropriative and prescriptive rights are not tied to specific land, transfers of the allocations associated with these rights could potentially be carried out more consistently with California groundwater rights law. However, as we have noted, surplus water capable of supporting some or all appropriative rights might be available only infrequently or not at all in some basins, especially those subject to critical conditions of overdraft, making them less useful for redistributing water in basins already experiencing significant water stress. On the other hand, allowing transfers of allocations related to overlying rights would seem to be inconsistent with the common-law groundwater rights that SGMA explicitly preserves.[258]

FIGURE 3. Summary of groundwater right characteristics that may be relevant for markets. This figure gives a flavor for some of the potential differences in the characteristics and constraints associated with common-law groundwater rights and rights to recover imported water (1) during times when groundwater surplus to the needs of overlying users is available (the paler column of each pair) and (2) during times when there is no surplus (the darker column of each pair). For example, when there is no surplus water in a basin, appropriative rights are technically unavailable and therefore lack exclusivity, divisibility, transferability, and enforceability. On the other hand, the unquantified, correlative nature of overlying rights likely gives them low exclusivity and makes them indivisible and difficult to enforce, while their linkage to specific overlying land might make them untransferable. Readers should not treat this figure as conclusive. Instead, it is meant to spark further consideration of potential differences in characteristics that may be relevant for local groundwater markets based on transfers of groundwater extraction allocations.



In its 2000 opinion in *City of Barstow v. Mojave Water Agency*, the California Supreme Court explained that "[a]n overlying right, analogous to that of the riparian owner in a surface stream, is the owner's right to take water from the ground underneath for use on his land within the basin or watershed; it is based on the ownership of the land and is appurtenant thereto."[259] Just as a riparian right may only be transferred along with the riparian land to which it is linked (see **Appendix B**), absent an adjudication, an extraction allocation associated with an overlying right might only be transferable with the overlying land it serves.

Under this interpretation, given the major substantive differences between groundwater rights, the most straightforwardly defensible transfer rules would bar overlying users from trading their groundwater extraction allocations to other landowners and would allow appropriative users to trade only when surplus water is available under their priority of right. Therefore, transfer rules used in adjudicated areas may not necessarily be appropriate models for transfer rules under SGMA (**Box 5**). For example, in some adjudicated areas, allocations associated with overlying rights can be transferred separate from overlying land (**Table 2; Boxes 2, 4, and 5**). The Amended Decision in *California American Water v. City of Seaside* set up two types of production allocations "roughly similar to appropriative and overlying rights, [but] reflecting a compromise by the landowners in that overlying rights are not fixed in quantity."[260] If overlyers chose to, they could convert their "Alternative Production Allocations" into "Standard Production Allocations" that could be transferred, but at the cost of losing the "prior and paramount right" to receive the amount of the Alternative Production Allocation "in perpetuity."[261] Both assigning overlying users a guaranteed volume in perpetuity and allowing them to convert this allocation into a transferable one might be legally questionable in an unadjudicated area. SGMA, GSPs, and allocations made under them cannot change or determine rights, and allocations cannot be used subsequently as final determinations of rights.[262] While the Seaside adjudication "creates a means to take advantage of market-based reallocations of water rights," it does so "in a manner that," under this interpretation, "would not be available under the common law."[263]

As we discussed in **Part III.C.4**, GSAs and their stakeholders could seek clarity either by asking the legislature to spell out the relationship between groundwater extraction allocations and groundwater rights or by proactively pursuing a statutory adjudication that determines groundwater rights, establishes groundwater extraction allocations, and settles questions about their transferability.

Interpretation 2: The transferability of groundwater extraction allocations is not constrained by the characteristics of existing groundwater rights

Some have suggested that, because it is not itself a groundwater right, the transferability of a groundwater extraction allocation is not constrained by the characteristics of the related groundwater right. In this view, ownership of a groundwater right would be a precondition for transferring an allocation, but the characteristics of that right need not affect the allocation's transferability.[264]

A groundwater market pilot program

Managers in some basins subject to SGMA are already beginning to explore the possibilities for groundwater markets. The Fox Canyon Groundwater Management Agency is one of the farthest along. It is gearing up for a one-year groundwater market pilot program in one of the basins it manages. For the past few years, agricultural users across the Agency's management area have received Annual Efficiency Allocations based on a crop Irrigation Allowance Index.[265] The pilot program would allow up to 30 agricultural water users within the Oxnard Basin to participate in a market based on transfers of all or part of each user's "market allocation"—the amount of groundwater that user reported pumping from August 2014 through July 2015—to other agricultural users in the basin.[266] Participants must install a smart meter or other Advanced Metering Infrastructure device, must have stayed within their Annual Efficiency Allocation for 2014–15, and must otherwise remain in compliance with the pilot program's rules and other ordinances and regulations.[267] The Agency plans to use the program as a learning experience, seeing it as a "reasonable means of evaluating" how helpful groundwater markets might be in "achiev[ing] the sustainability goals for the basins within its jurisdiction."[268]

Stakeholder engagement

As we discussed for developing groundwater extraction allocations (**Part III.C.4**), GSAs would be wise to use robust stakeholder engagement processes to help them decide if, when, and how different categories of groundwater rights should be transferrable. This will be especially critical for GSAs that are thinking about allowing transfers of extraction allocations held by overlying users, or by appropriative users whose groundwater rights are technically not available under conditions of overdraft.

KEY TAKEAWAYS

The key takeaways are similar to those for **Part III.C**: Because the relationship between groundwater extraction allocations and groundwater rights is not clear, GSAs should develop transferability rules through robust stakeholder engagement processes that foster stakeholder buy-in; furthermore, some GSAs may decide that pursuing a statutory adjudication that clarifies the transferability of groundwater extraction allocations would be a worthwhile step to take along the road to sustainable management.

BOX 5. Transfer rules and results of trading in California's adjudicated areas

Again, the 29 adjudicated areas listed in SGMA face different legal constraints than the unadjudicated areas of basins subject to SGMA. Specifically, to the extent that transfer rules developed through adjudications are founded in consent-based departures from standard conceptions of groundwater rights, they may not be appropriate for use in areas subject to SGMA (**Box 2**).

Most California groundwater adjudications allow at least a subset of the parties to engage in groundwater transfers.[269] Some adjudications allow transfers of allocations related to appropriative or prescriptive rights only, but others put all rights on equal footing or otherwise allow allocations associated with overlying rights to be transferred (**Table 2** includes some examples).[270]

Results of trading in adjudicated areas

A recent review of California adjudications commissioned by the SWRCB indicates that most transfer activity has shifted groundwater from overlying agricultural uses to municipalities or other water purveyors.[271] Similar shifts might be expected to occur if GSAs institute local groundwater markets under SGMA and allow allocations related to overlying rights to be transferred.

C. Potential impacts of trades in local groundwater markets

Unrestricted or poorly administered transfers could result in negative externalities, including the undesirable results SGMA requires GSAs to avoid. These can have overlapping spatial, temporal, method and purpose of use, social, and environmental dimensions.

1. Spatial dimensions

> CONSIDERATIONS:
>
> - How might transfers of groundwater extraction allocations change the spatial impacts of pumping and using groundwater?

Spatial patterns of groundwater extraction and use matter. Transfers that physically move water from one basin to another can cause negative impacts in the area of origin. For example, environmental and economic conditions changed dramatically in Owens Valley after the City of Los Angeles purchased much of the land and began to export large amounts of groundwater from the Valley.[272]

However, basin exports are not the only concern (and may be a minor concern for local groundwater markets developed under SGMA). Groundwater markets have the potential to redistribute, concentrate, and qualitatively transform the social and environmental impacts of pumping.[273] Changing the location of groundwater pumping within a basin can change its impacts. Pumping, or using, a particular volume of groundwater in one location may have greater (or lesser) impacts on people and ecosystems than pumping or using the same amount of groundwater in another location.

One important factor is how quickly the aquifer responds to groundwater extraction. In a simplified hypothetical basin in which the impacts of pumping are transmitted instantaneously throughout the groundwater system, the impacts of groundwater extraction would not depend upon where pumping occurred—instead, the primary factor would be the overall amount of groundwater extracted from the basin, and groundwater market constraints would need no further definition beyond a basin-wide cap on extractions per unit time.[274]

However, few groundwater systems are "so transmissive that the spatial distribution of extraction does not matter."[275] Even in a basin with uniform subsurface characteristics, lower transmissivity would cause cones of depression to develop around groundwater extraction points. Wells that are close together can interfere with one another, causing even greater local drawdown within their overlapping zones of influence. Similarly, pumping close to interconnected surface waters has greater potential to cause near-term surface water depletion than pumping further away.

Another important factor is how conditions vary across the basin. A broad range of basin characteristics influences the spatial distribution of impacts from pumping at any given location.[276] Geologic, hydrologic, social, and biological factors and patterns of existing groundwater use can lead some areas of a basin to be more susceptible to experiencing some of the undesirable results SGMA seeks to avoid, making increased pumping in these areas more likely to cause or contribute to their development. For example:

- Areas experiencing high rates of pumping may be more susceptible to chronic lowering of groundwater levels, degraded water quality, and reductions in the amount of groundwater in storage. Areas with heavier consumptive groundwater use may be even more susceptible to these undesirable results.
- Coastal areas may be more susceptible to water-quality degradation from seawater intrusion. For example, coastal areas of the Pajaro Valley are experiencing increased groundwater salinity caused by unsustainable levels of pumping that have pulled the seawater / freshwater interface miles inland.[277]
- Areas adjacent to places in which agricultural or industrial chemicals have been released into soil or groundwater may be more susceptible to water quality degradation associated with increased pumping. Changes in pumping patterns could cause subsurface contaminant plumes to spread faster, slower, or in different directions, potentially impacting the quality of water available in different parts of the basin.
- Although significant subsidence can occur in unconfined aquifer systems as well, areas above confined aquifer systems may be especially susceptible to compaction that causes land surface subsidence and a permanent loss of groundwater storage capacity. The negative repercussions of subsidence may be amplified in areas with critical infrastructure or where subsidence exacerbates the potential for seawater intrusion.
- Pumping in areas adjacent to rivers and other surface waters may be more likely to cause near-term depletions of surface water that impact groundwater dependent ecosystems.[278] Increased extractions in these areas could adversely affect sensitive animals or plants, for example protected salmon runs.[279]

GSAs can design trading rules that account for spatial variation in pumping impacts, being mindful that time lags (see below) can make understanding the impacts of pumping in different locations more challenging.

2. Temporal dimensions

> CONSIDERATIONS:
>
> - How might transfers of groundwater extraction allocations change the near-term, long-term, and delayed temporal impacts of pumping and using groundwater?
> - How might transfers of carried over portions of groundwater extraction allocations affect temporal impacts?

Trading rules may need to address temporal issues including pumping impacts that vary in time, lagging impacts, and the extent to which carry over of unused groundwater extraction allocations is appropriate.

Impacts that vary in time

The impacts of groundwater extraction at a particular location might be different at different times, for example, during wet vs. dry years, during the spring vs. the summer, or when no other neighbors are pumping vs. when many neighbors are pumping at the same time.[280] Trading rules can be designed to address this variation by imposing sustainability thresholds, establishing closure dates during which trading is not allowed, or requiring compliance with a coordinated pumping schedule that avoids excessive drawdown.

Time lags between pumping and its impacts

The effects of pumping in a particular location may take seconds, days, months, or many years to be felt by other water users or groundwater dependent ecosystems[281] and may differ for different sustainability indicators and undesirable results. For example, in a confined aquifer, head changes may occur across large distances relatively quickly due to changes in system pressurization associated with pumping.[282] By contrast, a contaminant plume in the same system may migrate much more slowly, but may be just as, if not more, concerning over the longer term.[283] Time lags can make it difficult to understand, or to muster support for addressing, cause and effect relationships between actions and outcomes.[284] GSAs should work to understand and address lagging impacts with appropriate trading rules.

Unintended consequences from carry over

SGMA give GSAs the power to develop accounting rules that allow unused groundwater extraction allocations to be carried over and transferred only "if the total quantity of groundwater extracted in any five-year period is consistent with the provisions of the [GSP]."[285] This provision potentially enables greater flexibility for conjunctive use, allowing water users to pump more groundwater during drier years and to use more surface water during wetter years, but its implications are not entirely clear.[286] Additionally, the accuracy of the assumptions that underlie the accounting rules GSAs develop and the effectiveness of oversight and enforcement will play critical roles in their success.

Using a groundwater extraction allocation during the year in which it was assigned will have different impacts than carrying over all or part of that allocation and using it in a later year. If not appropriately managed, carry over credits could accumulate to dangerous levels that are incompatible with sustainable management. For example, in the Fox Canyon groundwater basin, groundwater users accumulated carry over credits in excess of the entire sustainable yield of the basin, causing the management agency to suspend the exercise or accumulation of credits beginning in 2014.[287]

In some basins, there may be adequate unused storage capacity to accommodate carry over, which could have largely positive externalities (e.g., raising groundwater levels, potentially reducing pumping costs, improving groundwater quality, and helping to maintain important groundwater / surface water connections). However, in others, such as basins with little unused storage capacity or rapid flow-through, carry over and related withdrawals could be problematic.[288] Therefore, carry over provisions should be carefully crafted in a way that acknowledges basin realities and avoids the buildup of unsustainable levels of carry over credits.

3. Method and purpose of use dimensions

> CONSIDERATIONS:
>
> - How might transfers that change the method and purpose of use potentially affect the amount of groundwater consumptively used, return flows, and recharge? How might they affect water quality?

Changes in the method or purpose of groundwater use, as might occur as a result of transfers of groundwater extraction allocations in a local groundwater market, can affect the amount and quality of water available to other users and uses of water in a given hydrogeologic context. Additionally, different uses may have different tolerances for reduced water quantity or quality.

Water quantity

All of the undesirable results SGMA requires GSAs to avoid are directly or indirectly related to groundwater quantity.[289] Most beneficial uses consume some portion of the applied water while the remainder becomes available to others through return flows to surface water or percolation to groundwater.[290] The portion that is consumptively used includes losses from evaporation and transpiration; incorporation into biomass by plants, animals, and people; and contamination.[291]

The amount of water rendered unavailable for reuse varies for different methods of moving and applying water. For example, more efficient conveyance and irrigation technologies conserve water by reducing evaporation and conveyance losses, but they reduce the amount of return flow and percolation that occurs per unit of water applied.[292] Covered or enclosed conveyance infrastructure reduces losses to the atmosphere (evaporation) while lined canals reduce losses to groundwater (infiltration). Similarly, irrigation via drip or micro-sprinkler systems conserves applied water relative to flood irrigation.[293]

The amount of water needed and the amount of water rendered unavailable for reuse varies for different types of water use.

Economically valuable permanent crops, like fruit and nut trees, may offer greater financial returns per unit of water applied than annual crops, but they also provide less flexibility in the face of hydrologic uncertainty.[294] They require considerable up-front investments of resources, and they result in a hardening of water demand. Permanent crops need water every year to stay alive, and fallowing them means losing potentially substantial returns on investments.

Switching from agricultural to municipal groundwater use may also harden demand and reduce groundwater recharge. If treated municipal wastewater is not recycled or intentionally recharged, it is generally discharged into a waterway that then flows out of the basin. As urban conservation efforts during and after droughts have shown, there is still room to improve urban water-use efficiency by replacing water-guzzling fixtures and appliances, changing water-wasting behaviors, modifying landscaping, and developing alternative water supplies such as stormwater and recycled water.[295] However, this capacity is not unlimited, and it is generally not feasible to "fallow" a city.

Water quality

Among the undesirable results SGMA requires GSAs to avoid is significant and unreasonable degradation of water quality.[296] Changes in how water is used and what it is used for can change the attendant water quality implications of trading.

Different methods of moving and applying groundwater and different types of water use can have different effects on basin water quality. Transfers that shift the method or type of use can change the water quality impacts in a basin. For example, in a given hydrogeologic context, some irrigation methods are more likely to cause pollutants to build up in soils while others are more

BOX 6. The "no-injury" rule

Water transfers, whether of surface water or groundwater, should not cause injury to other legal users of the resource. A transfer that reduces the amount or quality of water that would otherwise have been available to other water rights holders exceeds the scope of the right and is unlawful.[297] For surface water transfers, this concept is codified in several state statutes. It boils down to the right to transfer only the portion of water that would otherwise have been consumptively used under the right and, therefore, only the amount that would already have been unavailable to downstream users (**Appendix B**). This amount is not straightforward to measure, but is instead generally inferred based on the facts and circumstances of the transferor's use.[298]

In the context of groundwater transfers, the no-injury rule is supported by the case law that defines groundwater rights (**Parts III.C and IV.B**). By definition, the exercise of an overlying right should not injure other overlying rights holders by denying them their reasonable share of the basin's safe yield. Appropriative rights are only technically available during times of surplus, and more junior appropriative rights must yield to more senior ones. However, somewhat paradoxically, groundwater use in violation of these rules—in other words, groundwater use that injures other legal users of groundwater—can result in the acquisition of prescriptive rights.

Separation of the surface water and groundwater rights systems has sometimes meant that the no-injury analysis for a surface water transfer may not fully account for impacts to groundwater users.[299] Similarly, the impacts of groundwater pumping and transfers on surface water rights have sometimes been incompletely addressed. However, this may change in coming years. Existing tools, specifically California's constitutional requirement for reasonable use (**Part III.C.3**) and the Public Trust Doctrine,[300] can be used to help bridge this gap.[301] GSAs will also need to implement SGMA's requirement to avoid significant and unreasonable adverse impacts to beneficial uses of surface water.[302]

likely to flush pollutants into groundwater.[303] When water is used to grow crops, keep recreational fields and golf courses green, or for public or private landscaping, related fertilizer and pesticide use can contribute to groundwater contamination.[304] Similarly, livestock-related water use can contribute contaminants like nutrients, antibiotics, and bacteria.[305] Other uses, from fossil-fuel development to residential, commercial, and industrial use, can produce spills, runoff, and wastewater that contribute directly or indirectly to groundwater contamination.

Additionally, different uses may have different tolerances for reduced water quality. For example, high salinity water may be inappropriate for agricultural use, nitrate-laden water poses public health risks, and water that is too warm may harm fish populations.

4. Social dimensions

CONSIDERATIONS:

- How might transfers of groundwater extraction allocations negatively affect people within the basin? Outside the basin?
- What communities and segments of the population might be especially at risk of experiencing, or being negatively affected by, undesirable results?

Changes in the location, timing, and method and purpose of water use that accompany groundwater transfers have the potential to cause adverse social impacts, which are frequently related to the undesirable results SGMA seeks to avoid.[306] For example, transfers could cause increased pumping in some areas, leading local groundwater levels to decline; local groundwater quality to worsen; to rising pumping costs, poorer water quality, increased water treatment needs, and subsidence that damages critical water infrastructure.[307]

Individually and collectively, these impacts can reduce water affordability, decrease water security, and increase the vulnerability of already disadvantaged communities and individuals.[308]

Groundwater trading can affect different people, and different segments of a basin's population, in different ways. For example, those with shallower wells may experience greater impacts from increased levels of local pumping. In some instances, when water is transferred for use outside of the local community, for the transferor, "wealth is transformed from water to cash," but "everyone else who has been benefiting from the presence of that water … in place will be made worse off, since the water is gone and they receive nothing in return."[309]

Those likely to be hardest hit include people whose jobs depend on the presence of water, like agricultural workers and others who work in agriculture-dependent communities, especially low-income workers who lack the resources necessary to move and find better employment opportunities and community amenities.[310]

Joseph Sax suggested institutionalizing community interest in water by barring transfers from being "redistributive to the disadvantage of those in the … area [of increased pumping or diversion], both in human and natural terms," and requiring the price the purchaser pays to "take into account all the benefits the water has produced, not just those that have flowed to the holders of formal water rights."[311]

BOX 7. California's Human Right to Water Statute

In 2012, the California legislature passed the Human Right to Water Statute. It declares as state policy "that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" and requires state agencies to consider the policy when taking actions with bearing on these uses of water.[312] DWR and the SWRCB must take the Human Right to Water into account when developing policies, regulations, and grant criteria.[313] Of particular relevance to groundwater transfer programs put in place by GSAs is how these state agencies address the Human Right to Water in developing and updating policies and regulations that govern how they approach adequacy review of GSPs (and their implementation) and the timing, form, and substance of state intervention efforts. DWR's Emergency Regulations for GSPs expressly require DWR to "consider the state policy regarding the human right to water when implementing the[m]."[314]

5. Environmental dimensions

CONSIDERATIONS:

- How might transfers of groundwater extraction negatively affect environmental resources?
- What ecosystems or species might be especially at risk of experiencing, or being negatively affected by, undesirable results?

All of the undesirable results described by SGMA have explicit environmental dimensions. Chronic lowering of groundwater levels, reduction in storage, degradation of water quality, seawater intrusion, land subsidence, and adverse impacts on beneficial uses of interconnected surface water are all, by nature, environmental impacts that can affect animals, plants, and ecosystems in addition to people.[315]

GSAs will need to consider how transfers of groundwater extraction allocations might affect environmental resources, including sensitive ecosystems and species, in their basins. What is known and not known about these resources? To what extent do they depend on groundwater or on interconnected surface water? Where will it be important to avoid increasing pumping? Where might species be at risk from reduced pumping (e.g., where fallowing agricultural land to make water available for transfer could harm species that have become dependent on local agricultural water use, like the giant garter snake[316])?

KEY TAKEAWAYS

Unrestricted or poorly administered transfers could result in negative externalities, including the undesirable results SGMA requires GSAs to avoid. These can have overlapping spatial, temporal, method and purpose of use, social, and environmental dimensions.

D. Trading rules

CONSIDERATIONS:

- How will rules sufficiently address the various dimensions of potential trading impacts?
- How might rules minimize the negative—and maximize the positive—impacts of trades?
- How will rules address information gaps and uncertainty?

If a GSA decides to employ a local groundwater market, it will need to establish and enforce rules to ensure that trades are lawful and sufficiently address the potential trading impacts discussed above. Rules should ensure that each trade would maintain or improve basin sustainability.[317] They can be tailored to basin conditions and goals in a way that maximizes the positive impacts of trades on third parties and the environment.

Table 4 provides examples of the types of rules GSAs might use to ensure that trades in local groundwater markets based on transfers of groundwater extraction allocations further sustainable management.

Trading ratios can be established to address differences in the likely impacts of increasing (or decreasing) pumping in different locations (**Figure 4**). For example, if groundwater dependent ecosystems are more stressed in the buying area—where increased extraction would occur after the trade—than in the selling area, then the trade is barred. If groundwater dependent ecosystems are more stressed in the selling area than in the buying area, the trade can proceed but is subject to the applicable trading ratio. If groundwater dependent ecosystems in the buying area are also stressed, the buyer pumps some fraction less water than the seller could have pumped, absent the trade. If groundwater dependent ecosystems are not stressed in either area, the buyer pumps the same amount the seller could have pumped. Finally, if groundwater dependent ecosystems in the selling area are stressed, while ecosystems in the buying area are not, the buyer might be allowed to pump some fraction more water than the seller could have pumped.

While trading rules may increase some transaction costs associated with groundwater trading,[318] they may decrease others. If rules are clear and well understood by groundwater users, they can enhance the predictability and transparency of the transfer approval process and reduce the administrative burdens on management agencies.

KEY TAKEAWAYS

GSAs may need to establish trading rules, tailored to basin needs, to ensure that trades minimize negative impacts to third parties and the environment and further sustainable management.

TABLE 4. Examples of potential trading rules for local groundwater markets based on transfers of groundwater extraction allocations.[319]

Rule basis	Examples
Consumptive use limitation	Only the amount of the groundwater extraction allocation that would otherwise have been consumptively used is available for transfer.
Trading zones	Trading zones can be defined to increase the net social and environmental benefits of transfers of groundwater extraction allocations. Specific transfer restrictions (see other rules) can apply to trading within a zone. Specific transfer restrictions (see other rules) can apply to trading between zones.
Trading ratios (exchange rates)	Trading ratios can be calculated to ensure that transfers of groundwater extraction allocations result in social or environmental benefits. The buyer receives the right to pump less, or more, groundwater than the seller could have pumped based on the relative impacts of pumping and use in each location. For an example, see **Figure 4**.
Directional restrictions	Over time, "sell-only" zones can progressively create low-groundwater-extraction buffers around groundwater dependent ecosystems, disadvantaged communities that rely on groundwater, or other sensitive areas.
Cumulative extraction limits	Transfers of groundwater extraction allocations that would cause cumulative extractions in the basin or trading zone to exceed an overall pumping limit are not allowed.
Spatial concentration limits (general)	Trading of groundwater extraction allocations is allowed up to a proportional or volumetric limit (e.g., allocations amounting to up to a specific percentage of the cap may be traded), and higher extraction fees apply in areas of concentrated pumping.
Spatial concentration limits (specific)	Trading restrictions are designed to limit the concentration of pumping near sensitive areas (e.g., limits on total extractions allowed within a particular distance of a stream or other groundwater dependent ecosystem or within a particular distance of a disadvantaged community that relies on groundwater).
Hydrologic connectivity	Trading can occur only within hydrologically connected areas.
Sustainability thresholds	Trading is prohibited when a sustainability indicator crosses a specified threshold.
Closure dates	Trading is prohibited during specified time periods.
Carryover limits	Unused portions of groundwater extraction allocations that are carried over can be traded within a specified number of years, at a specified ratio (e.g., 1/X of the original amount), up to a specified volume (e.g., not to exceed a specific percentage of the seller's seasonal allocation), and/or up to a specified cumulative volume (e.g., not to exceed a specific percentage of the overall pumping limit).

FIGURE 4. Trading ratios could be designed to protect groundwater dependent ecosystems.[320] For example, proposed transfers of groundwater extraction allocations to buyers in areas with more stressed groundwater dependent ecosystems (GDEs) could be barred to avoid increasing the stress on those GDEs. On the other hand, a transfer from an area with stressed GDEs to an area without stressed GDEs might entitle the buyer to pump more groundwater than the seller could have pumped, while a transfer to an area with less stressed GDEs might be allowed to go forward, but might entitle the buyer to pump less than the seller could have pumped.

E. Trading system and transfer approval process

CONSIDERATIONS:

- How will potential buyers and sellers find one another?
- What will the transfer approval process involve?
  - What environmental review will be needed for proposed transfers of groundwater extraction allocations? Will long-term or permanent transfers be allowed, and, if so, how will this affect environmental review requirements?
  - How will the approval process address potential impacts to other water rights?
- How and when will the parties to a transfer demonstrate that they meet environmental review, and other, requirements?
- How will trading rules be operationalized? If an electronic trading platform will be used, who will design, operate, and maintain it?
- How will completed transfers be tracked and confirmed?
- What trading-related information will be available to the public, when, and in what format?

Once trading rules are established, parties that are interested in participating in a groundwater transfer program will need to find one another, determine whether (and under what conditions) a trade is possible, demonstrate that they meet environmental review (**Table 1, Appendix B**) and other applicable requirements, obtain GSA approval, and implement the trade. Therefore, GSAs will need to consider how to structure the trading system and transfer approval process to minimize participants' transaction costs and maximize their compliance with trading rules and other requirements.

While trades can be arranged individually by parties, the transaction costs of ad hoc trades can be high.[321] Some form of market intermediary, like an exchange or broker, may be helpful. An exchange is a trading platform that matches buyers with sellers and coordinates documentation required for trade approval.[322] Exchanges can use automated matching processes or serve as simple bulletin boards that allow parties to peruse potential trading partners.[323] They can be designed to facilitate one-to-one trades, pooling of offers to buy and sell, or both.[324] Private brokers are intermediaries that explore potential trading options for their clients and complete required documentation.[325] They can use proprietary trading platforms or publically accessible exchanges to conduct trades.[326]

Markets are not efficient or effective when both of the parties to a trade do not know enough to make an informed decision or when there is a significant power differential between the parties.[327] A well-designed electronic exchange can help level the field by minimizing information asymmetry, reducing market bias, and efficiently operationalizing complex sets of trading rules.[328] An electronic trading platform can simplify the process of tracking trading rules, ensuring that trades comply with them, providing timely price information, and helping qualified potential market participants find one another. However, they are not always transparent, or as efficient as they could be.[329]

KEY TAKEAWAYS

GSAs will need to consider how to structure the trading system and transfer approval process to minimize participants' transaction costs and maximize their compliance with trading rules and other requirements, including environmental review.

V. General considerations

Beyond the foundational considerations and market-specific considerations outlined above, a suite of additional considerations is important for all groundwater sustainability programs. For example, GSAs will need to establish and maintain monitoring systems that help them understand how program activities affect basin conditions. They will need to exercise oversight and enforcement authority to ensure compliance with program requirements, evaluate program effectiveness, and address problems by making needed changes. Transparency and public engagement will be important throughout. Finally, developing and implementing sustainability programs will require sufficient resources, including human capacity, physical and technological infrastructure, and funding.

These considerations are as critical for local groundwater markets as for other sustainability programs. Any contrary assumption would be misplaced.

A. Monitoring

CONSIDERATIONS:

- What is known about the physical and temporal relationships between groundwater extraction, groundwater use, and basin conditions? How do these relationships vary across the basin?
- What is known about how other factors, such as changes in climate or land use, have affected basin conditions in the past and are likely to affect them in the future?
- Going forward, how will changes in basin conditions be monitored?
  - How will the impacts of groundwater extraction and use in general, and the impacts of transfers of groundwater extraction allocations in particular, be monitored?
  - What new technical expertise will be needed to monitor basin conditions and understand the effects of transfers?

As is often observed, you can't manage what you don't monitor.[330] Ongoing measurement of groundwater extractions (**Part III.A**) and monitoring and modeling of basin conditions are foundational requirements for sustainable management.[331] GSAs, basin stakeholders, and state regulators need to understand the movement of groundwater within the basin and the impacts of management decisions on basin resources and undesirable results. They need to be able to estimate how changes in climate and land use have affected basins conditions in the past and are likely to affect them in the future. Finally, they need to be able to evaluate whether the programs, systems, and rules GSAs put in place are adequate and being implemented in a way that actually achieves program goals.

The quality and coverage of existing information about basin conditions varies substantially across the state. Although strides have been made in developing groundwater information in recent years, there is still considerable room for improvement.[332] For example, in response to a 2009 legislative mandate, the California Statewide Groundwater Elevation Monitoring (CASGEM) Program now provides critical information about seasonal groundwater levels in many basins around the state, including much recently incorporated historical data.[333] But its coverage is incomplete,[334] and groundwater level monitoring does not address the full range of undesirable results SGMA seeks to avoid. In-depth studies exist for some areas of the state and for some sustainability indicators,[335] but very little is known about others. Significant gaps remain.[336]

GSAs will need to develop monitoring programs to understand changing basin conditions; how groundwater extraction, groundwater use, and management actions impact sustainability indicators; and progress toward meeting sustainability goals. DWR's Emergency Regulations for GSPs require each GSA to "develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation."[337] The regulations set out requirements for each sustainability indicator, shown in **Table 5**. As this report discusses, impacts can vary significantly in time and in space, as well as by the method or purpose of groundwater use (**Part IV.C**).

Monitoring will be essential for helping GSAs understand trading impacts and externalities.[338] It should be targeted to address questions like: How much groundwater is being pumped in the basin? When? Where? How is it being used? What are the impacts of pumping on basin conditions in space and time? How might transfers change these impacts? How have transfers changed these impacts? Many trading impacts may have complex indirect relationships with groundwater pumping, and so may be difficult to monitor.

Additional infrastructure and technical expertise may be needed to support monitoring and modeling to understand the effects of transfers on basin conditions. Examples include meters on individual production wells, public monitoring wells, stream gauges, and computing hardware and software to help organize and analyze data. As **Part III.A** explained, SGMA authorizes GSAs to require pumpers to meter and report their annual extractions. However, GSAs may need more detailed extraction data (e.g., reported on a monthly basis) to adequately understand seasonal variations in groundwater demand and the interaction of pumping and basin conditions.

KEY TAKEAWAYS

GSAs will need to develop monitoring programs to understand changing basin conditions; how groundwater extraction, groundwater use, and management actions—including transfer programs—impact sustainability indicators; and progress toward meeting sustainability goals.

TABLE 5. **What must monitoring accomplish for each sustainability indicator?**[339]

Sustainability indicator	Requirement
Chronic lowering of groundwater levels	Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods: (A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer. (B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.
Reduction of groundwater storage	Provide an estimate of the change in annual groundwater in storage.
Seawater intrusion	Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.
Degraded water quality	Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the [GSA], to address known water quality issues.
Land subsidence	Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.
Depletions of interconnected surface water	Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following: (A) Flow conditions including surface water discharge, surface water head, and baseflow contribution. (B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable. (C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction. (D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

B. Oversight and enforcement

CONSIDERATIONS:

- How will compliance with limits on overall groundwater extractions be tracked and ensured?
- How will compliance with groundwater extraction allocations, trading rules, and other program requirements be tracked and ensured?
  - How will voluntary compliance be encouraged?
- How will fair and consistent enforcement of groundwater extraction allocations, trading rules, and other program requirements be achieved?

Effective oversight and enforcement will be critical for implementing all groundwater sustainability programs, including local groundwater markets, successfully. For programs that limit groundwater pumping, GSAs will need to ensure compliance with overall limits on groundwater extractions and with individual groundwater extraction allocations. GSAs that employ groundwater markets will also need to ensure that transfers actually comply with applicable trading rules and other requirements. Timely and accurate measurement and reporting of groundwater extractions (**Part III.A**) will allow regulators to identify and take appropriate enforcement actions for violations.

GSAs' enforcement activities must be viewed as legitimate and credible.[340] They can promote voluntary compliance and shared resource stewardship through their actions.[341] GSAs need to engage in active oversight of metering and reporting requirements, groundwater extraction allocations, trading rules, and other program requirements coupled with timely and appropriate enforcement to correct violations.[342] They also need to hold themselves to the overall extraction limits developed for the basin and for any management areas. GSAs can maintain guidance that explains what is required of market participants, and why. Explicit enforcement policies, priorities, and procedures can also help establish clear expectations for transfer participants, as can information about the circumstances and outcomes of actual enforcement actions.

KEY TAKEAWAYS

GSAs will need to exercise effective oversight and ensure adequate enforcement of their sustainability programs, including groundwater markets. They will need to ensure that pumpers comply with their groundwater extraction allocations and that transfers actually comply with applicable trading rules and other requirements.

C. Evaluation

CONSIDERATIONS:

- When and how will program decisions and processes be evaluated?
- How will the assumptions and models that underlie limits on overall groundwater extractions, groundwater extraction allocations, and trading rules be assessed?
- How will the success of sustainability programs be evaluated?

A key component of any sustainability program is periodic evaluation of how well it is working. GSAs bear primary responsibility for evaluating program effectiveness and the assumptions and models that underlie limits on total groundwater extractions, groundwater extraction allocations, trading rules, and other aspects of their sustainability programs. SGMA requires GSAs to periodically evaluate "whether the actions under the plan are meeting the plan's management objectives and whether those objectives are meeting the sustainability goal in the basin."[343] GSAs must also "assess changing conditions" and other information "that may warrant modification of the plan or management objectives."[344]

In addition to periodic evaluation, it will be helpful to identify specific triggers, like negatively trending sustainability indicators, that can help GSAs catch potential problems in the making.

GSAs will need to identify what methods and criteria they will use to evaluate their programs. For example, how will they determine to what degree a local groundwater market is actually furthering sustainability and contributing to progress toward achieving measurable objectives? GSAs need to efficiently process and use the critical feedback they receive about the impacts of local groundwater markets from monitoring, modeling, and oversight activities.

A second layer of responsibility for evaluation rests at the state level. SGMA tasks DWR and the SWRCB with ensuring that each basin achieves necessary milestones and, ultimately, basin sustainability (**Box 8**). This includes periodically reviewing and evaluating the adequacy of GSPs and GSA's actual implementation efforts.[345]

If evaluation suggests local groundwater markets are not meeting benchmarks—or that the assumptions and models underlying extraction limits, allocations, and trading rules have not borne out—GSAs will need to implement modifications.

KEY TAKEAWAYS

GSAs should establish time lines or triggers and evaluation criteria to measure progress towards sustainability program goals and determine whether changes are needed.

D. Modification

CONSIDERATIONS:

- When and how will program elements and processes be updated?
- What mechanisms will trigger or enable changes to sustainability programs that respond to lessons learned, new information, and increased understanding of basin conditions?

Timely adoption of needed improvements will be critical to the success of groundwater sustainability programs.[346]

It would be difficult for GSAs to design programs that, right from the start, fulfill expectations and continue to do so, without any modifications, into the future. Evaluations may reveal that sustainability

BOX 8. State guidance, oversight, and intervention will form an important backstop by ensuring that local groundwater markets actually further sustainable management.

Although GSAs are tasked with the bulk of the work of sustainably managing medium- and high-priority groundwater basins, two state agencies also have important roles to play in SGMA implementation. DWR and the SWRCB have the authority and the responsibility to ensure that plans developed and implemented under SGMA—including local groundwater markets—are successful. For SGMA to be effective, DWR and the SWRCB must fully inhabit their critical guidance, oversight, and intervention roles.

Guidance — Implementing SGMA presents GSAs with a host of challenges that most water managers have not faced before. In this context, state-level coordination and dissemination of guidance could be crucial. A local groundwater market based on transfers of groundwater extraction allocations is one of many tools potentially available under SGMA that is sorely in need of additional guidance. DWR is responsible for laying the ground rules for GSAs through regulations,[347] developing best management practices for sustainable groundwater management,[348] and providing other important information.[349] It would be helpful for DWR to develop (or highlight) best management practices or other guidance for evaluating the utility of, designing, and implementing local groundwater markets. Both a set of general considerations (like those outlined in this report and summarized in **Table 6**) and a series of specific examples or illustrative scenarios would help GSAs to translate groundwater transfer authority from promising theory into effective practice.

Oversight — If a GSA includes a local groundwater market in its GSP, it will be reviewed for adequacy.[350] DWR, in consultation with the SWRCB, will determine whether the plan appears likely to achieve sustainable management.[351] After implementation begins, these agencies must then determine whether implementation efforts are adequate.[352] In either case, a timely and robust state response could drive needed improvements.

Intervention — Finally, the SWRCB has the power to intervene in basin management if GSAs do not meet their responsibilities. The SWRCB has the authority to put a basin on probation if planning deadlines are missed, if plans are inadequate, or if plan implementation efforts fall short in ways that are likely to jeopardize the achievement of sustainable management.[353] After a waiting period, the SWRCB can develop and implement an interim management plan until GSAs work through their problems.[354]

How SWRCB intervention in basin management will play out is not yet clear. GSAs may choose to emphasize projects that increase water supply or to implement a mix of projects and programs that increase supply and limit demand. However, the SWRCB has flagged that its intervention efforts will likely "focus on demand management (i.e., pumping restrictions) to reduce water use to meet a sustainability goal" and that "[m]etering of extractions will be necessary to verify compliance with pumping restrictions, will be at the pumper's expense, and will include associated reporting and extraction fees."[355] This is further reinforcement of the idea that GSAs looking to implement local groundwater markets will need to build in foundational metering / measurement requirements and exercise adequate oversight and enforcement in order to satisfy state regulators.

programs are not meeting critical objectives or that there are problems with the assumptions and models that underlie limits on total groundwater extractions, groundwater extraction allocations, trading rules, or other aspects of sustainability programs. Initial information about basin conditions will be less than optimal in many areas, and changes in information quality, climate, water demand, and groundwater management activities will create a constantly shifting playing field.

GSAs will need to adaptively manage their programs to ensure that they remain on track to achieve sustainability goals. Over time, GSAs will develop deeper knowledge of the basins they manage and gain on-the-ground experience implementing their sustainability programs. Monitoring management impacts and evaluating progress towards meeting specific measurable objectives will inform their selection and modification of management strategies.[356] Linking consideration of program modifications to the results of program evaluations can help ensure that critical short-comings are identified and appropriately addressed. This structured exploration is one of the primary features that distinguishes adaptive management from simple trial and error.[357] For example, in Australia's Murray-Darling Basin, volumetric caps on water use within resource management units must be periodically evaluated to determine whether "environmental, social and economic outcomes [would be] … maintained or improved by making adjustments.[358]

Some assumptions and decisions will be tested and found wanting, while others will hold firm. A GSA's growing knowledge base may support revisions to program components. For a local groundwater market, these components could include: the boundaries of basin management areas, models, overall groundwater extraction limits and individual allocations, market goals, trading rules, transfer approval processes, the trading system, monitoring and modeling protocols, oversight and enforcement activities, methods and triggers for evaluation, modification procedures, mechanisms for information sharing and stakeholder engagement, and what human capacity, infrastructure, and financial resources are needed to effectively design and implement the program.

While sudden disruptive changes to a sustainability program could be problematic, GSAs can do scenario and contingency planning to think through what types of changes might be necessary under different sets of circumstances and how to implement them in ways that minimize negative consequences. For example, GSAs might limit adjustments within an established range or make more substantial changes incrementally, in phases.

KEY TAKEAWAYS

GSAs will need to adaptively manage local groundwater markets and other sustainability programs to ensure that they actually contribute to sustainable management.

E. Transparency and public engagement

CONSIDERATIONS:

- How will information relevant to developing and implementing sustainability programs be communicated to the public?
- How will broad and meaningful public engagement in program development, implementation, and evaluation be ensured?
- What information about the actual operation of sustainability programs (e.g., about market transactions) will be available and in what contexts?
- What information will be shared about program oversight, enforcement, evaluation, and modification activities? How and when will this information be shared?

Robust public engagement, and the transparency it requires, will be critical for deciding whether a local groundwater market is an appropriate tool for achieving sustainable management in a particular area and for developing and implementing a successful program. During program development, robust engagement processes can provide critical information, diverse perspectives, and creative ideas that help GSAs craft more effective management solutions, all while cultivating broad stakeholder support. During program implementation, stakeholder engagement will be important for evaluating how well the program is working, whether and what changes are needed, and whether initial assumptions actually bear out in practice.

GSAs will be making decisions that affect a broad spectrum of stakeholders, including the general public, in the basins they manage. There are many reasons for GSAs to engage these stakeholders directly in developing, implementing, and evaluating its GSPs and programs, including those related to groundwater markets.[359]

First, the law requires it. SGMA calls on GSAs to engage the public in decision making. Each GSA must publicize how interested parties can participate in GSP development and implementation[360] and must also "encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the [GSP]."[361] These "elements of the population" are wide ranging, as SGMA requires GSAs to "consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing [GSPs]."[362] SGMA's non-exhaustive list of these interests spans those with overlying groundwater rights, agricultural users, domestic well owners, municipal well operators, public water systems, local land-use planning agencies, environmental users of groundwater, users of surface water that has hydrologic connections with groundwater, federal government entities, California Native American tribes, disadvantaged communities, and entities that monitor and report groundwater elevations.[363] Anyone who submits a written request to a GSA will be placed on the agency's list of "interested persons" who will automatically receive "notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents."[364] Additionally, a GSA must hold a public hearing before adopting or amending a GSP.[365]

Second, broad and meaningful public participation can help GSAs do their jobs better. Stakeholders of all types have the potential to contribute additional information, insights, perspectives, and suggestions. Engagement can occur on a number of levels, ranging in formality and depth. For example, SGMA allows GSAs to organize one or more advisory committees composed of "interested parties" to help them develop and implement GSPs.[366] DWR has long encouraged groundwater management entities to establish advisory committees.[367]

Finally, public participation is closely linked to perceptions of transparency and fairness. The decisions GSAs make could negatively impact some parties while positively impacting others. The absence of broad and meaningful[368] stakeholder engagement can create a perception that decisions are being made behind closed doors in a way that favors limited stakeholder interests.[369] For example, in the Paso Robles Basin, voters recently turned down the creation of a Special Act district to manage area groundwater because it was seen as developed and supported by a narrow range of interests.[370] Although it can be challenging to achieve, sincere commitment to robust public engagement will increase public acceptance of and confidence in a GSA's decisions and decrease the likelihood and severity of future conflicts over these decision, and water resource management more broadly.[371]

Meaningful public engagement is a two-way street that requires ongoing investments of time and resources on the part of GSAs. In order to make it work, GSAs will need to actively provide information and education to the public regarding SGMA, basin conditions, SGMA implementation options and their potential impacts, and specific decisions and their actual impacts.[372] They will need to reach out to and seek input from groups and individuals with diverse interests and perspectives, providing accessible venues and formats for public input and feedback.[373] GSAs can build thoughtful solicitation and consideration of public comments and suggestions into each step in their decision-making processes.

KEY TAKEAWAYS

Robust public engagement, and the transparency it requires, will be critical for deciding whether a local groundwater market is an appropriate tool for achieving sustainable management in a particular area and for developing and implementing a successful program.

F. Resources

GSAs will need adequate human capacity, infrastructure, and financial resources to carry out their responsibilities under SGMA, including analyzing basin conditions and developing and implementing a suite of sustainability programs to achieve sustainable management.

1. Human capacity

CONSIDERATIONS:

- What skills and expertise will be needed to design and implement effective sustainability programs?
- How will these capacities be developed or accessed?

To successfully implement SGMA, GSAs will need to develop or access a range of skills and expertise. For GSAs that employ local groundwater markets, these include the following human capacities:[374]

- Technical experts who can design and maintain monitoring systems and other infrastructure; collect, analyze, and interpret monitoring data; model basin history and the potential consequences of different management options for basin groundwater resources; identify sustainability indicators, minimum thresholds, measurable objectives, and interim milestones to gauge undesirable results and progress toward sustainability; translate these into overall pumping limits (including sustainable yield for the basin) and, in the case of local groundwater markets, trading rules that appropriately account for changes in the method and purpose of use, spatial issues, and temporal issues.

- Legal and policy experts who can help identify and address applicable local, state, and federal law; develop management plans that include effective regulatory controls; navigate legal ambiguities associated with groundwater rights; design an effective transfer approval process and trading system; establish appropriate oversight, enforcement, evaluation, and modification protocols; assist with developing transparency and public engagement protocols; and investigate non-compliance and carry out enforcement actions.
- Communication experts who can facilitate broad and meaningful public engagement during both the planning and implementation phases of GSPs by sharing technical and legal information in accessible ways and soliciting input on potential future actions and feedback on past or ongoing actions from diverse stakeholders; and interact effectively with regulated groundwater users.
- Management experts who can run the GSA efficiently and effectively and coordinate with other GSAs and other local and state agencies.
- Financial experts who can develop funding sources and mechanisms.

Some of these capacities will be needed in-house, while others could be accessed through consultants or through technical assistance from other local agencies or DWR.[375]

2. Physical and technological infrastructure

CONSIDERATIONS:

- What infrastructure will be needed to carry out sustainability programs?
    - What infrastructure will be needed to measure groundwater extraction and use?
    - What infrastructure will be needed to monitor basin conditions and understand the effects of transfers?
    - What computing hardware and software will be needed to organize and analyze data, develop models, etc.?

GSAs will need to ensure that there is adequate physical and technological infrastructure to support their sustainability programs. Examples include meters on individual production wells, monitoring wells, stream gauges, and computing hardware and software.

3. Funding

CONSIDERATIONS:

- How will sustainability programs be funded?

Finally, GSAs will need to secure funding to support all aspects of their sustainability programs.[376] This includes monitoring infrastructure, land and facilities purchases, staff salaries and consultant fees, public education and outreach expenses, computing hardware and software, operation and maintenance costs, among other things.

Some expenses—like the purchase, installation, and maintenance of meters—may be most effectively funded directly by groundwater users on an individual basis. Similarly, those participating in local groundwater markets can cover costs specifically associated with their transactions, like the transfer approval process and expenses related to transfer oversight. Other expenses, like capital expenditures, may be well-suited to grant or bond support. Still others may be better-suited to an ongoing source, like groundwater extraction fees or other groundwater-management-related fees. This includes expenses related to initial GSP development and ongoing expenses like program design and program implementation, including monitoring, oversight and enforcement, evaluation and modification efforts, and infrastructure operation and maintenance. There is currently significant legal ambiguity surrounding the use of fees as a funding mechanism in light of the constraints on local agencies introduced by Propositions 13, 218, and 26.[377]

KEY TAKEAWAYS

GSAs will need adequate human capacity, physical and technological infrastructure, and financial resources to carry out their responsibilities under SGMA.

VI. Conclusion

As they develop paths to achieving sustainable groundwater management, GSAs and the stakeholders they serve will need to analyze a range of management options, comparing the expected benefits and burdens of each.

This report aims to help GSAs and other stakeholders gauge the viability one of many potential tools they might use to achieve sustainable management under SGMA: local groundwater markets. SGMA potentially opens the door for local groundwater markets based on transfers of groundwater extraction allocations. However, it does not provide guidance about the circumstances under which specific transfers, or a transfer program more generally, might be useful and appropriate additions to GSAs' sustainability programs.

While, in the abstract, relying on markets may sound like a straightforward and politically palatable solution to local groundwater management challenges, our research suggests that GSAs should approach them with a cautious, analytical eye. Factors like local climate, geology, hydrology, ecological resources and needs, legal requirements, social and economic conditions, and basin goals will affect market viability. These factors may vary significantly from basin to basin, as well as within a single basin.

We outline a set of considerations (summarized in **Table 6**) designed to help GSAs and others evaluate whether a local groundwater market based on transfers of groundwater extraction allocations might be a viable sustainable management tool in a particular groundwater basin. These considerations are organized into three groups: (1) foundational considerations shared in common with other programs that limit groundwater pumping, (2) market-specific considerations, and (3) general considerations that are important for all groundwater sustainability programs. When discussing these considerations, the report points out legal ambiguities and other sources of uncertainty that may present challenges for those seeking clarity about market programs.

Cross-cutting observations include the following:

- GSAs are responsible for ensuring that their sustainability programs, including local groundwater markets based on transfers of groundwater extraction allocations, contribute to sustainable management under SGMA.
- Whether a local groundwater market might be a viable tool for furthering sustainable management of a particular groundwater basin will depend on a host of basin-specific factors.
- Well-designed and implemented local groundwater markets could potentially contribute to socially, environmentally, and economically desirable reallocation of groundwater resources in some basins.
- Carefully designed trading rules will be needed to ensure that trades support progress toward sustainability and sufficiently address negative impacts to third parties and the environment.
- Local groundwater markets may not be viable management options where the potential impacts of trading are not well understood, where trading rules cannot sufficiently address negative externalities, or where—relative to other management options—the expected benefits of a market do not outweigh the burdens and uncertainties associated with designing and implementing it.
- GSAs will need to consider the relationship between groundwater rights and groundwater extraction allocations when establishing allocations and developing transferability rules.
- Effective monitoring, oversight and enforcement, adaptive management of all aspects of the program will be crucial for market success.
- Developing and implementing a local groundwater market that successfully furthers sustainable management under SGMA will require significant ongoing effort.

In conclusion, although markets are no panacea, they have the potential to further sustainable management in some basins. Well-designed and implemented markets that are geared toward minimizing the negative, and maximizing the positive, impacts of trades could play a role in efficiently reallocating groundwater extraction and use to achieve better alignment with sustainability goals in many basins. However, for some GSAs, a local groundwater market may not be viable.

As California's experiment with sustainable groundwater management enters its next phase, whether and how local groundwater markets might play a role in achieving basin sustainability will be questions of interest to GSAs, the stakeholders they serve, and state agencies with oversight and intervention responsibilities. We hope the considerations and analysis outlined in this report help inform basin-specific answers and, ultimately, the development of effective sustainability programs around the state.

TABLE 6. Critical considerations for local groundwater markets under SGMA. To successfully design and implement local groundwater markets that further sustainable management under SGMA, GSAs will need to analyze and appropriately address a set of complex, interwoven considerations grouped here into three categories: (1) foundational considerations, (2) market-specific considerations, and (3) general considerations.

1. Foundational considerations	
Measuring groundwater extractions	• What is known about historical groundwater extraction and use in the basin? • How well understood are current patterns and volumes of groundwater extraction and use? • How will groundwater extraction and use be measured going forward?
Setting overall pumping limits	• How will the total amount of groundwater that may be pumped from the basin (and, if appropriate, from different management areas) be determined? - What sustainability indicators, minimum thresholds, measurable objectives, and interim milestones will be used to gauge undesirable results and progress toward sustainability? - How will these be translated into sustainable yield for the basin and, if appropriate, to extraction limits for different management areas?
Establishing individual groundwater extraction allocations	• What is the relationship between groundwater extraction allocations and common-law groundwater rights? • How adversarial are basin stakeholders? How open to cooperative solutions are they? • What factors will be used to determine individual groundwater extraction allocations? • To what extent should differences in the characteristics of groundwater rights be accounted for in the allocation process? Under conditions of overdraft, will appropriative users still receive allocations? How will probable prescriptive uses be addressed? • How will the allocation system address the dormant overlying rights of landowners not currently making overlying use of groundwater? How will it address landowners that want to begin new overlying uses in the future? • What groups would benefit most, and least, from different allocation options? • How should return flows to surface water or percolation to groundwater from the use of imported and native surface water be addressed? • Will those issued allocations be able to carry over some or all of an unused portion for future use? If so, how much, for how long, and under what conditions?

2. Market-specific considerations		
Market goals		• What is the market intended to accomplish (or avoid)? • How will the market complement or reinforce other sustainability programs? • How will market success be measured?
Groundwater rights questions		• To what extent should the characteristics of groundwater rights affect the transferability of groundwater extraction allocations? • How might transfers of groundwater extraction allocations injure other water users?
Potential trading impacts	Spatial dimensions	• How might transfers of groundwater extraction allocations change the spatial impacts of pumping and using groundwater?
	Temporal dimensions	• How might transfers of groundwater extraction allocations change the near-term, long-term, and delayed temporal impacts of pumping and using groundwater? • How might transfers of carried over portions of groundwater extraction allocations affect temporal impacts?
	Method and purpose of use dimensions	• How might transfers that change the method and purpose of use potentially affect the amount of groundwater consumptively used, return flows, and recharge? How might they affect water quality?
	Social dimensions	• How might transfers of groundwater extraction allocations negatively affect people within the basin? Outside the basin? • What communities and segments of the population might be especially at risk of experiencing, or being negatively affected by, undesirable results?
	Environmental dimensions	• How might transfers of groundwater extraction allocations negatively affect environmental resources? • What ecosystems or species might be especially at risk of experiencing, or being negatively affected by, undesirable results?
Trading rules		• How will rules sufficiently address the various dimensions of potential trading impacts? • How might rules minimize the negative—and maximize the positive—impacts of trades? • How will rules address information gaps and uncertainty?
Trading system and transfer approval process		• How will potential buyers and sellers find one another? • What will the transfer approval process involve? - What environmental review will be needed for proposed transfers of groundwater extraction allocations? Will long-term or permanent transfers be allowed, and, if so, how will this affect environmental review requirements? - How will the approval process address potential impacts to other water rights? • How and when will the parties to a transfer demonstrate that they meet environmental review, and other, requirements? • How will trading rules be operationalized? If an electronic trading platform will be used, who will design, operate, and maintain it? • How will completed transfers be tracked and confirmed? • What trading-related information will be available to the public, when, and in what format?

3. General considerations		
Monitoring		• What is known about the physical and temporal relationships between groundwater extraction, groundwater use, and basin conditions? How do these relationships vary across the basin? • What is known about how other factors, such as changes in climate or land use, have affected basin conditions in the past and are likely to affect them in the future? • Going forward, how will changes in basin conditions be monitored? - How will the impacts of groundwater extraction and use in general, and the impacts of transfers of groundwater extraction allocations in particular, be monitored? - What new technical expertise will be needed to monitor basin conditions and understand the effects of transfers?
Oversight and enforcement		• How will compliance with limits on overall groundwater extractions be tracked and ensured? • How will compliance with groundwater extraction allocations, trading rules, and other program requirements be tracked and ensured? - How will voluntary compliance be encouraged? • How will fair and consistent enforcement of groundwater extraction allocations, trading rules, and other program requirements be achieved?
Evaluation		• When and how will program decisions and processes be evaluated? • How will the assumptions and models that underlie limits on overall groundwater extractions, groundwater extraction allocations, and trading rules be assessed? • How will the success of sustainability programs be evaluated?
Modification		• When and how will program elements and processes be updated? • What mechanisms will trigger or enable changes to sustainability programs that respond to lessons learned, new information, and increased understanding of basin conditions?
Transparency and public engagement		• How will information relevant to developing and implementing sustainability programs be communicated to the public? • How will broad and meaningful public engagement in program development, implementation, and evaluation be ensured? • What information about the actual operation of sustainability programs (e.g., about market transactions) will be available and in what contexts? • What information will be shared about program oversight, enforcement, evaluation, and modification activities? How and when will this information be shared?
Resources	Human capacity	• What skills and expertise will be needed to design and implement effective sustainability programs? • How will these capacities be developed or accessed?
	Physical and technological infrastructure	• What infrastructure will be needed to carry out sustainability programs? - What infrastructure will be needed to measure groundwater extraction and use? - What infrastructure will be needed to monitor basin conditions and understand the effects of transfers? - What computing hardware and software will be needed to organize and analyze data, develop models, etc.?
	Funding	• How will sustainability programs be funded?

Appendix A: Examples of existing groundwater markets

Markets involving groundwater transfers exist in a number of countries. Small-scale transfers of groundwater occur informally in many parts of the world. Informal markets generally rely on physical transfers of water across short distances from neighbors with wells to neighbors without wells. Formal markets have been documented in at least a handful of countries, most notably Australia,[378] and in a number of western U.S. states,[379] including in adjudicated areas of California (**Boxes 2, 4**, and **5**).[380] Below, several international, U.S., and California examples provide a flavor for the variety present in these existing groundwater markets.

Informal markets in South Asia

Informal groundwater markets based on the physical transfer of pumped water have been noted in Pakistan, India, Nepal, and Bangladesh.[381] They develop in areas where groundwater use is largely unregulated and the cost of building new wells or powering pumps is higher than many water users, like small and marginal farmers, can afford.[382] Well owners, who are often farmers themselves, pump water for neighbors in exchange for labor, fuel, shares of a crop, or cash.[383] A 1988 study in Punjab, Pakistan, found that close to 30% of farmers owned wells, while one-third bought groundwater from their neighbors.[384] Other studies suggest that between 33 and 88% of well owners in parts of South Asia sell at least some groundwater to others.[385] These informal markets may be socially beneficial in the short-term, providing more equitable access to water resources, enabling greater agricultural productivity, and increasing employment opportunities.[386] However, they also have the potential to exacerbate existing inequalities,[387] and, in the longer-run, uncontrolled groundwater extraction may lead to overdraft and increased groundwater scarcity that rolls back social gains.[388]

Australia

Australia's water market system is one of the largest and most active in the world,[389] yet, even there, trades of groundwater rights have been relatively uncommon. Most surface water entitlements in the country have been "unbundled" from land titles, allowing parties to sell or lease just their seasonal water allocation or their ongoing water access entitlement separately from the land.[390] However, many jurisdictions have not yet "fully unbundled" groundwater access (pumping) entitlements, and, even though about 49% (by number) and 21% (by volume) of water entitlements in the country are for groundwater entitlements, groundwater transfers remain limited.[391] National estimates suggest that, in 2012–13, only about 12% of permanent entitlement trading and 1% of short-term allocation trading involved groundwater.[392] Other factors that may contribute to low levels of groundwater trading include limited hydrogeological connectivity within and between aquifers, incomplete understanding of aquifer connectivity, and a lack of conveyance infrastructure.[393]

The Murray-Darling Basin, which spans five states and the Australian Capital Territory,[394] accounts for most of the water market trading in Australia (95% by volume), grows half of the nation's irrigated produce, and encompasses 40 Aboriginal Nations.[395] Reflecting the complex nature of its groundwater systems, the Basin has been divided into 66 different groundwater resource units, and each has been assigned a volumetric cap, known as a sustainable groundwater diversion limit, set to take effect in 2019.[396] In theory, these limits take into account the effects of groundwater use on the following: groundwater dependent ecosystems, groundwater / surface water interactions, salinity and other water quality parameters, and long-term aquifer productivity.[397] Interestingly, only 1 of the 66 groundwater resource units will need to reduce groundwater use to meet its cap, 34 others have caps equal to their baseline use, and the remaining 31 units are free to expand their groundwater use.[398] In fact, basin-wide, the long-term average sustainable diversion limit (3,334 gigaliters per year) is much higher than estimated baseline usage (2,386 gigaliters per year).[399] The Murray-Darling Basin Authority suggests that access and water quality issues in many areas make it unlikely that the basin-wide sustainable diversion limit will ever be exceeded.[400]

Trades of groundwater access rights are allowed within and between resource areas in the Murray-Darling Basin as long as certain conditions are satisfied.[401] For trades within a groundwater resource unit, the conditions include (1) "sufficient hydraulic connectivity between the two locations," (2) no exceedance of "any resource condition limits … specified in a water resource plan," (3) "substantially similar characteristics of timing reliability and volume" for water access rights in the two locations, or the existence of measures "to ensure the water access right will maintain its characteristics of timing reliability and volume," and (4) the existence of measures that address third-party impacts that would result from the trade.[402] Similar conditions are required for trade between groundwater resource units.[403] It is unclear how much groundwater trading has occurred in the Basin, since trading records have been insufficiently detailed to allow groundwater trades to be distinguished from so-called "unregulated" surface water trades.[404] However, collectively these two categories appear to have accounted for about 23% of permanent entitlement trades and less than 3% of short-term allocation trades.[405] As more attention is focused on groundwater resources in the Murray-Darling Basin, and its groundwater markets mature, the area promises to be a rich source of information and lessons learned about the role of groundwater transfers in groundwater management, and water resource management more broadly.

Edwards Aquifer, Texas

In 1993, the Texas legislature established the Edwards Aquifer Authority and gave it the authority to issue permits and regulate withdrawals to "protect[] threatened and endangered species in the aquifer-fed Comal and San Marcos springs," as required by the federal Endangered Species Act.[406] Texas follows the rule of capture and allows groundwater to be sold or leased separately from the land.[407] Groundwater permits were allocated according to each user's maximum beneficial use of water between June 1972 and May 1993.[404] Leasing or selling permitted groundwater rights is allowed, but none of the water may leave the Authority's jurisdiction, and a maximum of 50% of an irrigation right may be leased.[409] Transfers became much more common beginning in 2006, with an average of 446 transfers (most leases) occurring each year from 2006 to 2012, accounting for up to 12.5% of the permitted pumping volume.[410]

Upper Republican Natural Resource District, Nebraska

Nebraska's Upper Republican Natural Resource District overlies part of one of the world's largest groundwater systems, the High Plains aquifer system.[411] In 1979, the District became the first in the state to establish groundwater allocations and has subsequently reduced allocations by about 40%, slowing the rate of groundwater level declines in the basin.[412] Allocations are made for 5 years and depend on the end use of the water: water for agricultural irrigation is allocated on a per acre basis, water for commercial livestock is allocated on a per animal basis, water for municipal use is allocated on a mixed population and acreage basis, and industrial wells go through an application process.[413] Well metering and annual reporting are mandatory and violations are enforced.[414] Transfers of pumping rights must be approved by the District's board of directors, may only occur within a township or "floating township," may not enhance stream flow depletion, and may be restricted in the vicinity of other transfers or based on the total existing usage near the receiving well.[415] From January to November 2008, approximately 6 transfers of groundwater allocations occurred in the District, which contains more than 3,000 wells.[416]

Mojave Basin Area, California

The Mojave Basin Area adjudication, finalized in 2000, allows for permanent trading and temporary leasing of groundwater rights, allocations, and carried-over allocations within and between 5 subareas (**Box 4** and **Table 2**). Base Annual Production rights were defined based on prior use (the maximum annual production between 1986 and 1990). Aggregate annual Free Production Allowances are set for each subarea, with each pumper's share proportional to their Base Annual Production."[417] Parties can sell or lease all or part of their Base Annual Production Rights or annual allocations. Transfers within a subarea require notice to the watermaster, transfers between subareas require watermaster authorization, and groundwater exports require court approval.[418] The cost of administration, monitoring, and enforcement are paid for by volumetric administrative assessments on pumping by all parties, as is a trust fund for the protection of basin species and habitat.[419] During the 2014–15 fiscal year, there were 226 leases and 21 permanent transfers involving parties to the adjudication.[420]

Groundwater markets in other adjudicated areas

Information about groundwater transfers and trading in other adjudicated areas appears throughout the report but is concentrated in **Boxes 2, 4, and 5** and **Table 2** and associated endnotes.

Appendix B: Summary of surface water rights and lessons from surface water transfers

Although most information about groundwater transfers in California comes from adjudicated areas, California's experience with surface water transfers can also inform transfer programs GSAs might develop under SGMA. Different transfer limitations and requirements apply to different types of surface water rights: riparian rights, pre-1914 appropriative rights, and post-1914 appropriative rights.

Riparian rights can only be transferred jointly with riparian land

Under a riparian right, the owner of land adjacent to a surface watercourse has the right to use its natural flow for reasonable beneficial use on that land.[421] Like pre-1914 appropriative surface water rights, riparian rights are not subject to SWRCB permitting. Generally, water available under a riparian right cannot be stored or transferred separately from ownership of the riparian land.[422]

Transfers involving appropriative surface water rights

Acquiring an appropriative right does not depend on land ownership but on the actual taking of water. The priority of an appropriative right is determined based on the date of the initial diversion, or an act in furtherance of eventual diversion, with older rights having higher priority than more recent ones.

Pre-1914 appropriative rights

Initially, appropriation was solely a creature of common law. During the gold rush, miners adopted a "first in time, first in right" rule for the water they appropriated to mine placer deposits, and "California courts looked to principles of equity and of real property law to adjudicate conflicting claims."[423] At this point, appropriation involved simply "diverting it and putting it to use."[424] Beginning in 1972, state statute introduced the option of initiating an appropriative right by posting notice "in a conspicuous place at the point of intended diversion" and recording the notice with the county recorder.[425]

A change in the point of diversion, place of use, or purpose of use of a pre-1914 appropriative water right does not require the SWRCB's approval.[426] Nonetheless, changes, including changes involving transfers, must not cause injury to other legal users of water.[427] This restriction protects both senior water rights holders from junior diverters and junior water rights holders from changes that would reduce the quantity or quality of the water they legally rely upon.[428] It is typically interpreted to mean that the amount of water a water right holder can transfer is limited to the amount that would not change the quantity of water that would have been consumptively used, if not for the transfer.[429] The SWRCB adopted emergency regulations, effective on March 21, 2016, that require annual reporting of water transfers by pre-1914 appropriative users.[430]

Post-1914 appropriative rights

The 1913 Water Commission Act, which became effective on December 19, 1914, created a procedure for acquiring new appropriative rights.[431] Since then, would-be appropriators have been required to seek a permit from the SWRCB (or it's predecessor).[432]

The SWRCB's approval is required for a transfer that results in a change in the point of diversion, place of use, or purpose of use of a post-1914 appropriative water right. To approve a transfer involving a post-1914 appropriative surface water right, the SWRCB must find that the changes required for the transfer will not cause injury to other legal users of the water and will not unreasonably affect fish, wildlife, or other instream beneficial uses.[433] For a short-term transfer (lasting 1 year or less), the amount that can be transferred is explicitly limited to "the amount of water that would have been consumptively used or stored by the permittee or licensee in the absence of the proposed temporary change."[434] Such transfers are exempt from CEQA.[435] For an urgent temporary change involving a transfer (beginning soon and lasting 180 days or less, with the potential for renewal), the SWRCB must make all of the following findings: (1) the proposed change(s) will not cause injury to other legal users of the water; (2) there is "an urgent need to make the proposed change"; (3) the "change may be made without unreasonable effect upon fish, wildlife, or other instream beneficial uses"; and (4) the "change is in the public interest."[436] Post-1914 appropriative users must also report transfers of "contract water," even if no water right changes were involved.[437]

Additional requirements for transfers

Tansfers must also be consistent with other local, state, and federal laws. For example, any transfer that requires the discretionary approval of a state or local agency must comply with CEQA[438] unless an exemption applies, while compliance with the National Environmental Policy Act (NEPA)[439] is required for transfers that involve federal facilities. Transfers of pre- or post-1914 appropriative rights that require conveyance through State Water Project, the Central Valley Project, or regional or local agency facilities need the approval of the relevant agency.[440] Their analysis focuses on determining "the amount of surface water under the transferor's right that can be transferred without injuring other users,"[441] and ensuring that the transfer will not "unreasonably affect[] fish, wildlife, or other instream beneficial uses" or "the overall economy or the environment of the county from which the water is being transferred."[442]

Determining how much water is available for transfer

Certain information is required to support a surface water transfer. In general, this information is used to estimate the conditions that would have occurred in the absence of the transfer and the amount of water that is available for transfer, as well as to confirm that the actual transfer met applicable requirements. For example, DWR's information requirements for the 3 main types of surface water transfers[443] include the following:

- **Cropland idling (or crop shifting)** — Idling cropland that would otherwise have been in production during the transfer period (or shifting to lower-water-using crops) makes surface water available for transfer by reducing the amount consumptively used.[444] Therefore, transfer proposals must contain information sufficient "to support the claimed reductions in consumptive use of applied surface water."[445] This includes the acreage to be idled for transfer; cropping information for the past 5 years; maps showing field information, high seepage areas, and areas managed for wildlife habitat; and a maintenance and monitoring proposal for idled acreage.[446]
- **Groundwater substitution** — Using groundwater instead of surface water can make surface water available for transfer by effectively increasing the amount of surface water supply.[447] Therefore, a transfer proposal based on groundwater substitution needs to address increased pumping during the time conveyance infrastructure is available to convey the surface water for transfer and the extent and timing of surface water supply reductions caused by the increased pumping.[448] This involves documenting surface water rights, explaining how the amount of surface water available for transfer was quantified, describing the wells that would be used to pump groundwater, demonstrating the baseline groundwater pumping that would occur in the absence of the transfer, identifying a proposed schedule and volume for transfer-related pumping, and establishing monitoring and mitigation plans to assess the transfer's effects and alleviate potential injury to other legal users of water.[449] Groundwater substitution transfers that require SWRCB approval must be consistent with groundwater management plans adopted under state law or "[a]pproved by the water supplier from whose service area the water is to be transferred."[450]
- **Reservoir storage releases** — A seller makes water available for transfer by releasing more water from a reservoir than would otherwise be released under normal operating conditions.[451] Therefore, a transfer proposal must provide sufficient information to demonstrate normal operating conditions, the normal amount of water in storage at the end of the season, and typical patterns of reservoir releases during a variety of hydrologic conditions.[452] During the period of the transfer and the reservoir refill period, additional information—like stream gage, reservoir release, and reservoir storage data—will be needed to verify delivery of the transferred water and to account for refill impacts.[453] Reservoir refill criteria are used to help ensure that transfers do not injure other legal users of water.[454]

How are the limitations on surface water transfers relevant to groundwater transfers?

- Like riparian rights to use surface water, overlying rights to use groundwater are not straightforwardly separable from the associated land (**Part IV.B.1**). This may make it difficult for those with unadjudicated overlying rights to participate in local groundwater markets based on transfers of groundwater extraction allocations (**Part IV.B.2**).
- Some basic restrictions, including the no-injury rule (**Part IV.C.3**) and the requirement for reasonable and beneficial use (**Part III.C.3**), are common to both surface water and groundwater transfers.
- Surface water transfers must be supported by sufficient information to establish the amount of water available for transfer, verify the actual amount transferred, and ensure that the transfer does not injure other legal users and uses of water. Similar information will be needed to support groundwater transfers.

Appendix C: How other environmental markets have addressed trading externalities

Trading externalities arise in other environmental markets, including air pollution, water pollution, and fishery quota markets. A brief discussion of some of these externalities, and the mechanisms used to address them, follows.

Air pollution markets

Air pollution permit markets can be efficient tools for meeting air quality requirements[455] and have targeted pollutants responsible for acid rain,[456] smog,[457] and global warming,[458] among others. However, negative externalities can arise when the spatial distribution of regulated or co-occurring pollutants[459] changes as parties trade pollution allowances. Trades can create or perpetuate pollution "hot spots" of especially high concentrations of pollutants that pose public health or environmental risks, and the impacts of a certain level of emissions can vary from place to place due to differences in prevailing winds, local topography, population size or vulnerability, and other factors.[460] Some emissions trading programs have attempted to take into account spatial differences in the impacts of emissions and trades using mechanisms like rules that limit or bar trading between certain geographic areas (trading zones) and trading ratios that raise the costs of trades that contribute to hotspots.[461] Other issues are also important, such as whether the cap is set and then ratcheted down appropriately, how and to whom pollution allowances are allocated, and how well offset provisions are designed and implemented.[462]

Water pollution markets

Although markets have been less widely used to address water quality problems, they have been advocated as tools to more cheaply achieve the water pollution reductions required by national, state, and regional regulations.[463] Operational examples include nutrient trading programs in North Carolina's Neuse River basin[464] and in the Chesapeake Bay watershed.[465] Similar to air pollution markets, concerns include the development or maintenance of hot spots.[466] Again, appropriate trading ratios and trading zones that restrict the geographic area of trading may help prevent hotspots.[467] While the market fragmentation that accompanies the creation of trading zones can produce multiple "thin" markets with few buyers, few sellers, or both, research suggests this is not necessarily problematic.[468]

Fishery quota markets

Individual transferable quotas (ITQs), also known as catch shares, give individuals or entities a share of the total allowable catch from a particular fish stock.[469] An array of externalities can arise from ITQ markets.[470] For example, when one species is managed through an ITQ market, fishing pressures on species not managed through ITQs may increase.[471] A multispecies quota system that takes into account ecosystem linkages can address this externality.[472] ITQ markets do not inherently account for the specific physical location of harvest or the damage fishing gear does to benthic habitat, which can negatively impact both targeted and untargeted species.[473] One proposed solution is the creation of an individual habitat quota market, based on a proxy for marginal habitat damage, running in parallel with the ITQ market.[474] Left unchecked, these types of externalities jeopardize future ecosystem and fishery health, with implications for fishing communities, the fishing industry, and the end users of fishery products. Externalities can also be explicitly social. An ITQ market effectively consolidates fishing rights to fewer vessels that more efficiently exploit the fishery, with impacts to fishing communities[475] and individuals employed in fishery-related activities.[476] Possibilities for addressing these impacts include introducing community development quotas, crew quota shares, and processor quota shares and setting limits on the consolidation of quota shares. The Bering Sea and Aleutian Island Crab Rationalization Program[477] provides examples for three of these four options. The program allocated long-term shares of total allowable catch among vessel owners and western Alaskan fishing communities based primarily on historical participation, assigning different rights and responsibilities to each.[478] Each year, the total allowable catch is allocated among owner quotas and community development quotas.[479] Some allocation types carry specific requirements to deliver catch to regional land-based processors that hold individual processor shares or quotas.[480] Additionally, so-called "concentration caps" apply to vessel shares (1–10%, depending on crab stock), crew shares (2–20%, depending on crab stock), and land-based processors (30% of processor quota pool per fishery) to prevent particular individuals or companies from gaining excessive influence over the fisheries.[481]

Endnotes

1 *See* Tom G. Farr et al., Progress Report: Subsidence in California, March 2015–September 2016 1 (2017), *available at* http://www.water.ca.gov/waterconditions/docs/2017/JPL%20subsidence%20report%20final%20for%20public%20dec%202016.pdf; James W. Borchers et al., Land Subsidence from Groundwater Use in California ES-2–4 (2014), *available at* http://waterfoundation.net/wp-content/uploads/PDF/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf.

2 *See* A. Pidlisecky et al., *Electrical Resistivity Imaging of Seawater Intrusion into the Monterey Bay Aquifer System*, 54 Groundwater 255, 256 (2016).

3 *See* Laura Foglia et al., *Coupling a Spatiotemporally Distributed Soil Water Budget with Stream-Depletion Functions to Inform Stakeholder-Driven Management of Groundwater-Dependent Ecosystems*, 49 Water Resources Res. 7292, 7294–94 (2013).

4 *See* Jesse Reiblich & Christine A. Klein, *Climate Change and Water Transfers*, 41 Pepperdine L. Rev. 439, 447–48 (2014); James H. Skurray et al., *Hydrological Challenges to Groundwater Trading: Lessons from South-West Western Australia*, 412–413 J. Hydrology 256, 260 (2012) [hereinafter Skurray et al. 2012].

5 *See* Skurray et al. 2012, *supra* note 4, at 260.

6 *See* Cal. Water Code § 10726.4(a)(2).

7 *See, e.g.,* William F. Ritter & Jennifer de Mooy, *Groundwater Use in Agriculture: Approaches to Sustainable Management in U.S. Case Studies*, *in* World Environmental and Water Resources Congress 2014: Water Without Borders, at 335, 337–38 (2014) (describing "Irrigation Non-Expansion Areas" in Arizona, in which an increase in irrigated acreage is prohibited, and "Active Management Areas," in which irrigated acreage is limited and water allocations are incrementally reduced "to the amount of water deemed reasonable for specific crops"); Fox Canyon Groundwater Mgmt. Agency, Annual Report for Calendar Year 2014, at 10, 24, app. A (2015), *available at* http://www.fcgma.org/public-documents/reports (describing the crop "Irrigation Allowance Index").

8 A San Diego County ordinance requires development projects in the Borrego Valley Exemption Area that would "extract or use at least one acre-foot . . . of groundwater per year" to ensure "no net increase" in groundwater extractions by taking measures that "achieve[] permanent water savings." San Diego Cnty., Cal., Code Regs. Ordinances § 67.720; *see also* Borrego Water Dist., Demand Offset Mitigation Water Credits Policy 3–7 (last revised May, 19, 2015), *available at* http://www.borregowd.org/uploads/Water_Credit_policy_revision_05.19.2015.pdf.

9 SGMA authorizes two types of fees. First, a GSA can impose regulatory fees, "on groundwater extraction or other regulated activity, to fund the costs of a groundwater sustainability program," including costs related to planning, administration, performing investigations or inspections, providing compliance assistance, and carrying out enforcement. Cal. Water Code § 10730. **Second, property-related fees on groundwater extraction can fund the "costs of groundwater management," including administration, operation, and maintenance; acquisition of property, facilities, and services; and water supply, production, treatment, or distribution.** *Id.* § 10730.2**. Property-related fees must comply with Proposition 218.** *See id.* § 10730.2(c); *see also* Cal. Const. art. XIII D, § 6 (added by Prop. 218, § 4, approved Nov. 5, 1996)**. The circumstances under which groundwater extraction fees can be considered "regulatory" is unclear, however. Different California Courts of Appeal have come to potentially conflicting conclusions, and the California Supreme Court is currently reviewing the matter. Multiple decisions in the Sixth Appellate District have held groundwater extraction fees to be property-related fees imposed for water service, which are subject to Article XIII D but exempt from the requirement for voter approval.** *See Great Oaks Water Co. v. Santa Clara Valley Water Dist.*, 242 Cal. App. 4th 1187, 1197 (2015), *review granted and opinion superseded by* 367 P.3d 6 (Cal. 2016); *Griffith v. Pajaro Valley Water Management Dist.*, 220 Cal. App. 4th 586, 590 (2013); *Pajaro Valley Water Management Agency v. Amrhein*, 150 Cal. App. 4th 1364, 1369 (2007). **On the other hand, the Second Appellate District issued a 2015 opinion holding that a groundwater extraction fee was not property related, but regulatory, citing the different fee provisions in SGMA.** *See City of San Buenaventura v. United Water Conservation Dist.*, 235 Cal. App. 4th 228, 234 (2015), *review granted and opinion superseded by* 351 P.3d 328 (Cal. 2015).

10 Every individual or entity that pumps groundwater in the Orange County Groundwater Basin pays a $322 "replenishment assessment" per acre-foot of water extracted. *See* Orange Cnty. Water Dist., Budget Report: Fiscal Year 2015–16, at 8 (2015), *available at* http://www.ocwd.com/media/3303/budget-report-2015-2016.pdf; Orange Cnty. Water Dist., *OCWD Establishes 2015-2016 Basin Pumping Percentage and Price,* Hydrospectives OCWD Water News, July 2015 [hereinafter OCWD Water News], *available at* http://newsletter.ocwd.com/2015/ReadMore_2015-07_BasinPumpingPercentageAndPrice.aspx; *see also 80 Years of Successful Groundwater Management in Orange County,* Groundwater Act Blog, Feb. 23, 2015, http://www.water.ca.gov/cagroundwater/blog-ocwd.cfm.

11 The Pajaro Valley Water Management Agency imposes volumetric "augmentation charges" on groundwater pumped within its management area. The rate is higher within a coastal zone that has been experiencing gradual seawater intrusion. For the 2016–17 fiscal year, metered users pay $258 for each acre foot of groundwater pumped within this zone, and $203 per acre foot pumped outside it. *See Rates*, Pajaro Valley Water Mgmt. Agency, http://pvwater.org/about-pvwma/rates.php (last visited Aug. 8, 2016); *see also* Pajaro Valley Water Mgmt. Agency, Proposition 218 Service Charge Report 53–54 (Jan. 2015), *available at* http://pvwater.org/about-pvwma/assets/rates/Service_Charge_Report_%20Final_Jan2015.pdf. **Unmetered rural residential users pay a flat rate of $92 per residence per year (thought to work out to approximately $184 per acre-foot of groundwater pumped).** *Id.*

12 The Fox Canyon Groundwater Management Agency imposes groundwater extraction charges of $6.50 per acre-foot of groundwater extracted. *See* Fox Canyon Groundwater Mgmt. Agency, Resolution No. 2016-03, A Resolution Increasing Fee on Groundwater

Extractions to Fund the Costs of a Groundwater Sustainability Program, Jul. 20, 2016, *available at* http://www.fcgma.org/images/ordinances_legislation/Resolutions/Resolution_2016-03.pdf (exempting those who extract two or fewer acre-feet per year for domestic purposes); Fox Canyon Groundwater Mgmt. Agency, Cal., Ordinance Code § 2.4. **Prior to April 2014, pumpers could apply "conservation credits" earned from unused allocations to avoid surcharges for pumping more than their extraction allocations.** *See id.* §§ 4.6, 5.7.2.1.1, 5.8; *see also infra* note 287 and accompanying text.

13 **When an Orange County Water District member agency satisfies potable water demand by pumping more than the "basin production percentage" of groundwater instead of using alternative sources, it incurs a "basin equity assessment" of $587 per acre-foot, which reflects the cost of imported water.** OCWD Water News, *supra* note 10; *see also Water Glossary*, Orange County Water Dist., http://www.ocwd.com/media/3562/water-glossary.pdf**.**

14 **A City of Salinas ordinance imposes penalties of up to $200 per acre-foot when an "urban water purveyor" pumps "groundwater in excess of that purveyor's annual allocation" from the Salinas Valley Groundwater Basin.** Salinas, Cal., Code of Ordinances § 36A-9; *see also id.* § 36A-7(b) (defining "urban water purveyor").

15 **Under the Six Basins Area adjudication, individual producers who pump more than their allocation (plus carried over water, water acquired through transfers, and water recovered under a storage and recovery agreement) must pay a "replacement water assessment" to cover the costs of purchasing imported water to make up the difference.** *S. Cal. Water Co. v. City of La Verne et al.*, Case No. KC029152, at 8, 32 (Cal. Super. Ct. Dec. 18, 1998) (Six Basins Area stipulated judgment). **Other adjudication judgments contain similar provisions.** *See e.g.*, *City of Barstow, et al v. City of Adelanto, et al.*, Case No. 208568, at 30, 36 (Cal. Super. Ct. Jan. 10, 1996) (Mojave Basin Area judgment after trial); *Cal. Am. Water v. City of Seaside et al.*, Case No. M66343, at 13, 32 (Cal. Super. Ct. Mar. 22, 2006) (Seaside Basin decision).

16 **In April 2016, the Pajaro Valley Water Management Agency approved a pilot program for "Recharge Net Metering" developed with researchers at U.C. Santa Cruz and the Resource Conservation District of Santa Cruz County: for each unit of water recharged, a program participant will receive a 50% rebate of the unit water cost for water pumped from wells for the following year.** *See* Press Release: PV Water Launches Landmark Groundwater Rebate Program, Apr. 20, 2016, *available at* http://www.pvwma.dst.ca.us/media-room/news-releases/2016/Release1601-PV%20Water%20Launches%20Landmark%20Groundwater%20Rebate%20.pdf; Pajaro Valley Water Mgmt. Agency, Memorandum RE: Informational Item 12C: Consider Approval of a Proposal to Establish Recharge Net Metering (ReNeM) as a Pilot Program for Five Years, Acting General Manager, March 10, 2016; Tom Yulsman, *Parched California Tries to Grab Storm Water before It Escapes*, Scientific Am., Mar. 10, 2016, http://www.scientificamerican.com/article/parched-california-tries-to-grab-storm-water-before-it-escapes/.

17 *See* Cal. Water Code § 10726.2(b), (d), (e); *see also id.* § 10721(m) (defining "in-lieu use" as "the use of surface water by persons that could otherwise extract groundwater in order to leave groundwater in the basin").

18 **The Semitropic Water Storage District in Kern County operates a groundwater storage bank that stores surplus water, mostly derived from the "in-lieu recharge" that occurs when farmers use surface water provided by the District instead of pumping groundwater during wet years. When banking partners request stored water, it can be pumped and returned to State Water Project or Central Valley Project conveyance infrastructure for delivery.** *Groundwater Banking FAQs*, Semitropic Water Storage Dist., http://www.semitropic.com/GndwtrBankFAQs.htm (last visited March 12, 2017).

19 **The Pajaro Valley Water Management Agency delivers a blend of tertiary-treated recycled wastewater and other water supplies to agricultural users in some coastal areas of the basin that are experiencing or especially vulnerable to seawater intrusion.** *See* Pajaro Valley Water Mgmt. Agency, Basin Management Plan Update 4, 17, 19 (2014)*, available at* http://pvwater.org/about-pvwma/assets/bmp_update_eir_final_2014/BMP_Update_Final_February_2014_(screen).pdf. **Although the cost of delivered water ($359 per acre-foot) is currently greater than the cost of pumping groundwater in this zone ($258 per acre-foot), considerations like poorer groundwater quality and pumping costs may make delivered water a better option for many coastal irrigators.** *See Rates*, *supra* note 11. **As groundwater quality continues to degrade, reliance on delivered water will likely increase. This is an example of users balancing the cost and quality of different water sources.**

20 **SGMA contains a partial list of "interests" GSAs must consider.** *See* Cal. Water Code § 10723.2.

21 *Cf.* Micah Green, *Rough Waters: Assessing the Fifth Amendment Implications of California's Sustainable Groundwater Management Act*, 47 U. Pac. L. Rev. 25, 42–48 (2015) (discussing when a takings claim might "be cognizable" under SGMA).

22 **Earlier legislation created a number of special act districts tasked with groundwater management responsibilities.** *See* Water Educ. Found., The 2014 Sustainable Groundwater Management Act: A Handbook to Understanding and Implementing the Law 1 (2015), http://www.watereducation.org/sites/main/files/file-attachments/groundwatermgthandbook_oct2015.pdf. **General legislation provided incentives for voluntary management in other areas. In 1992, the legislature passed the Groundwater Management Act, authorizing any local agency that provides water service to develop and implement a groundwater management plan.** *See* 1992 Cal. Legis. Serv. ch. 947, § 2 ("A.B. 3030") (codified at Cal. Water Code §§ 10750–10755.4). **In 2002, amendments made funding from DWR for groundwater projects contingent upon plans containing basin management objectives, monitoring components, and other requirements.** *See* 2002 Cal. Legis. Serv. ch. 603 ("S.B. 1938"). **In 2011, further amendments specified that these requirements also applied to funding for "projects that are part of an integrated regional water management program or plan" and imposed additional requirements related to mapping and describing recharge areas.** *See* 2011 Cal. Legis. Serv. ch. 572 ("A.B. 359").

23 Cal. Water Code § 113.

24 *See id.* §§ 113, 10720.1.

25 **A GSA can be any "local public agency that has water supply, water management, or land use responsibilities within a groundwater basin," including a city, a county, a special district, or some combination of these agencies organized via a legal agreement.** *Id.* § 10721(n); *see also id.* §§ 10723(a); 10723.6(a). **If multiple local agencies notify DWR of their intent to form a GSA in the same area, the agencies must reach an agreement on how to proceed.** *See id.* § 10723.8(c).

26 *See id.* § 10727 (requiring plans for basins identified as critically overdrafted by January 31, 2020, and for other medium- and high-priority basins by January 31, 2022). **In lieu of forming a GSA and developing a groundwater sustainability plan, a local agency could submit an alternative that satisfies SGMA's objectives by January 1, 2017.** *See id.* § 10733.6. **Alternatives can be plans developed under other laws that authorize groundwater management, management under an adjudication, or a demonstration that the basin has operated within its sustainable yield for the last 10 years or more.** *Id.* § 10733.6(b).

27 *See id.* § 10727.2; *see also id.* § 10727(a) ("A groundwater sustainability plan shall be developed and implemented for each medium- or high-priority basin by a groundwater sustainability agency to meet the sustainability goal established pursuant to this part."); *id.* § 10721(u) (defining "sustainability goal" as "the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield").

28 *See id.* §§ 10727(b)(3), 10727.6, 10733.4(b).

29 *See e.g.*, Kirstin I. Conti & Joyeeta Gupta, *Global Governance Principles for the Sustainable Development of Groundwater Resources*, J. Int'l Envtl. Agreements: Politics, L. & Econ., at 3 (2015), doi:10.1007/s10784-015-9316-3.

30 **"Sustainable groundwater management" is "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results."** Cal. Water Code § 10721(v). **"Planning and implementation horizon" is "a 50-year time period over which a groundwater sustainability agency determines that plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield."** *Id.* § 10721(r).

31 *Id.* § 10721(x).

32 Cal. Water Code § 10721(w).

33 *See id.* § 10720.7(a). **The remaining very low- and low-priority basins can choose to follow SGMA's lead, but are not required to.** *See id.* § 10720.7(b). **These priority determinations flow from analysis of a set of eight basin criteria: the overlying population and its projected growth, the number of public supply wells and total wells, the amount of irrigated acreage, the degree of reliance on groundwater, the condition of groundwater resources, and other relevant information.** *See* Cal. Water Code § 10933(b); *Groundwater Basin Prioritization*, Cal. Dep't Water Resources, http://www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm (last modified Nov. 30, 2015).

34 *See Groundwater Basin Prioritization*, *supra* note 33.

35 *See id.* **Of these, 84 were medium priority and 43 were high priority.** *See id.*

36 *See California's Groundwater: Bulletin 118*, Cal. Dep't of Water Resources, http://water.ca.gov/groundwater/bulletin118/index.cfm (last modified Dec. 23, 2016); *Groundwater Basin Prioritization*, *supra* note 33. **Of these, 407 were unsubdivided basins and 24 basins were further subdivided into 108 subbasins.** *See* Cal. Dep't Water Resources, California's Groundwater: Bulletin 118, Update 2003, at 106 (2003) [hereinafter Bulletin 118, Update 2003], *available at* http://www.water.ca.gov/groundwater/bulletin118/report2003.cfm (noting that subbasins were often defined based on "public input, but little physical data"). **As GSAs begin to fill in information gaps and DWR reassesses basin prioritization, these numbers may change.**

37 **While basin prioritization takes into account a range of criteria, DWR separately identifies critically overdrafted basins, and SGMA gives them expedited time tables for developing GSPs.** *See* Cal. Water Code § 10727, 10720.7(a). **About 17% of medium- or high- priority basins fall into this category. Using a 1989 to 2009 base period, DWR identified 21 medium- or high-priority basins as "subject to critical conditions of overdraft" but noted that very limited data were available for more than 400 basins and that, for some basins, conditions may have worsened significantly after the base period.** *See* Cal. Dep't Water Resources, DWR Update: Critically Overdrafted Basins 2015 Draft List, Aug. 25, 2015, *available at* http://www.water.ca.gov/groundwater/sgm/pdfs/CriticalOverdraftPresentation_V8_final.pdf; *Critically Overdrafted Basins*, Cal. Dep't Water Resources, http://www.water.ca.gov/groundwater/sgm/cod.cfm (last modified Mar. 1, 2016).

38 *See* Cal. Dep't Water Resources, California's Groundwater: Working Toward Sustainability: Bulletin 118, Interim Update 2016 21 (2016) [hereinafter Bulletin 118, Interim Update 2016], *available at* http://www.water.ca.gov/groundwater/bulletin118/docs/Bulletin_118_Interim_Update_2016.pdf.

39 *See 2016 Bulletin 118 Interim Update*, Cal. Dep't Water Resources , http://www.water.ca.gov/groundwater/bulletin118/update.cfm (last modified Dec. 23, 2016). **In reprioritizing basins, DWR will consider an additional criterion, added by SGMA: "adverse impacts on local habitat and local streamflows."** Cal. Water Code § 10933(b)(8).

40 **SGMA specifically exempts 26 adjudicated areas, and 3 other areas it treats as adjudicated areas, from SGMA's planning and implementation requirements.** *See* Cal. Water Code § 10720.8(a)–(d). **Instead, these areas must annually report certain information about area groundwater resources and use to DWR.** *Id.* § 10720.8(f).

41 *See id.* § 10720.8 (exempting only specifically listed areas). **Amendments to SGMA passed in 2015 require courts to manage adjudication proceedings to "minimize[] interference with the timely completion and implementation of a groundwater sustainability plan" and to ensure "consisten[cy] with the attainment of sustainable groundwater management within the timeframes established by [SGMA]."** *Id.* § 10737.2. **A court can only "approve entry of judgment for a basin required to have a groundwater sustainability plan" if "the court finds that the judgment will not substantially impair the ability of a groundwater sustainability agency" or state regulators "to comply with . . .**
[SGMA] and to achieve sustainable groundwater management." *Id.* § 10737.8; *see also* Cal. Civ. Proc. Code §§ 830–852 (establishing new rules for comprehensive groundwater adjudications); Cal. Civ. Proc. Code § 850 (requiring comprehensive adjudication judgments to also be "consistent with Section 2 of Article X of the California Constitution" and "with the water right priorities of all non-stipulating parties and any persons who have claims that are exempted pursuant to Section 833 in the basin" and to "treat[] all objecting parties and any persons who have claims that are exempted pursuant to Section 833 equitably as compared to the stipulating parties").

42 **Shapefiles for CASGEM Groundwater Basin Prioritization (dated Aug. 3, 2015), Adjudicated Groundwater Basins (dated Sept. 28, 2016), and County Boundaries were downloaded from DWR's Groundwater Information Center Interactive Map Application.** *See Groundwater Information Center Interactive Map Application*, Cal. Dep't Water Resources, https://gis.water.ca.gov/app/gicima/ on March 12, 2017 [hereinafter *GICIMA*]. **Maps were initially created using open source QGIS software**, QGIS Development Team, Open Source Geospatial Foundation Project, QGIS Geographic Information System, http://qgis.osgeo.org (2016), **then edited using Adobe Illustrator. Critically overdrafted basins were identified based on DWR's 2016 Interim update to Bulletin 118.** *See* Bulletin 118, Interim Update 2016, *supra* note 38, at 11, 15 fig.2. **The boundaries of two areas SGMA treats as adjudicated areas that were not included in the available shapefile, but were shown in DWR's online mapping applications—the Inyo County Basins area and the Antelope Valley area—were approximated using Adobe Illustrator.** *See GICIMA, supra* this note; *Adjudicated Basin Annual Reporting*, Cal. Dep't Water Resources, http://sgma.water.ca.gov/webgis/index.jsp?appid=adjbasin (last visited Mar. 12, 2017); *see also* Cal. Water Code § 10720.8(b), (c).

43 **Although recently modified basin boundaries are available, current basin prioritizations were done using the unmodified boundaries, and updated prioritizations are not expected to be available until fall 2017.** *See Basin Boundary Modifications*, Cal. Dep't Water Resources, http://www.water.ca.gov/groundwater/sgm/basin_boundaries.cfm (last modified Oct. 28, 2016); *2016 Bulletin 118 Interim Update*, *supra* note 39 (noting that, "[i]n June 2014, DWR completed the basin prioritization process by sorting the 515 groundwater basins described in Bulletin 118, Update 2003 into four priority categories—high, medium, low, and very low").

44 *See* Cal. Water Code §§ 10725–10726.8, 10730–10731; *see also* Michael Kiparsky et al., Designing Effective Groundwater Sustainability Agencies: Criteria for Evaluation of Local Governance Options 16, 29 tbl.5 (2016), *available at* https://www.law.berkeley.edu/research/clee/research/wheeler/groundwater-governance-criteria/.

45 *See* Cal. Water Code § 10725.8 (allowing GSAs to mandate the purchase, installation, and maintenance of a satisfactory water-measuring device for non de minimis extraction facilities).

46 *See id.* § 10725.8(c).

47 *Id.* § 10726.4(a)(1).

48 *See id.* § 10726.2(b), (d). **GSAs can also appropriate, purchase, or transfer groundwater or groundwater rights.** *Id.*

49 *Id.* § 10726.4(a)(2) (emphasis added).

50 *See id.* § 10726.4(a)(3).

51 *Id.* § 10726.4(a)(3).

52 *Id.* § 10726.4(a)(4).

53 **For example, the Tehama County Flood Control and Water Conservation District is the exclusive GSA for 10 subbasins, while there are multiple exclusive GSAs already established within the Tule subbasin.** *See GSA Map Viewer*, Cal. Dep't Water Resources, http://sgma.water.ca.gov/webgis/index.jsp?appid=gasmaster&rz=true (last visited Mar. 12, 2017).

54 *Id.* § 10726.4(a)(3).

55 *Id.* § 10726.4(a)(4).

56 *Id.* § 10726.4(a)(3).

57 *See* Cal. Dep't Water Resources & State Water Resources Control Bd., Background and Recent History of Water Transfers in California 8 (July 2015) [hereinafter Transfer History], *available at* http://www.water.ca.gov/watertransfers/docs/Background_and_Recent_History_of_Water_Transfers.pdf.

58 **Water suppliers looking to export groundwater from certain "protected areas" need to comply with special California Water Code requirements if they initiated pumping after January 1, 1985.** Cal. Water Code §§ 1215, 1216. **Protected areas include the Sacramento, Mokelumne, Calaveras, San Joaquin, Truckee, Walker, Carson, and Russian River watersheds and the Mono Lake watershed.** *See id.* § 1215.5. **Exports cannot directly or indirectly deprive a protected area of "the prior right to all the water reasonably required to adequately supply the beneficial needs of the protected area, or any of the inhabitants or property owners therein."** *Id.* § 1216. **Additionally, if an export project is constructed consistent with the Water Code in a protected area, water users within the area have the right to purchase the resulting water for adequate compensation.** *Id.* § 1217; *see also id.* § 1218.

59 *See* Cal. Water Code § 1220. *But see id.* § 1220(d). **Specifically, groundwater pumping for export must comply with a groundwater management plan adopted by ordinance and subsequently approved by voters in the areas overlying the groundwater basin.** *Id.* § 1220(a), (b). **According to DWR and the SWRCB, this "effectively prevents the direct pumping of groundwater for uses outside the Sacramento Valley unless very stringent conditions are met."** *See* Cal. Dep't Water Resources & State Water Resources Control Bd., Water Transfers and the Delta Plan 24 (Sept. 16, 2015), *available at* http://www.water.ca.gov/watertransfers/docs/Water_Transfers_Report_to_DSC.pdf.

60 **In California, a permit is required to construct, modify, or destroy a groundwater well.** *See* State Water Resources Control Bd., A Guide for Private Domestic Well Owners 9 (2015), *available at* http://www.waterboards.ca.gov/gama/docs/wellowner_guide.pdf. **Wells must also comply with state-established well construction standards.** *Id.* **Counties, and sometimes cities, are the primary permitting authorities for these activities.** *See Well Permitting Agencies*, Cal. Dep't Water Resources, http://www.water.ca.gov/groundwater/wells/permitting.cfm (last modified Aug. 8, 2016). **In some counties, like Alameda County and Santa Clara County, one or more cities or local agencies also exercise well permitting authority.** *See id.* **As of 2014, 30 of California's 58 counties had adopted groundwater management ordinances that impose additional permitting requirements for some categories of groundwater extraction and use.** *See* Cal. Water Found., An Evaluation of California Groundwater Management Planning 12 (July 2014), *available at* http://www.groundwatervoices.com/cwf-an-evaluation-of-california-groundwater-management-planning/; *see also* Bulletin 118, Update 2003, *supra* note 36, at 39 tbl.4 (listing "[c]ounties with ordinances addressing groundwater management" and the key elements of their ordinances).

61 **Some local governments use their police powers to regulate the spacing of water wells relative to one another or to make permit approval contingent upon other conditions.** *See Baldwin v. County of Tehama*, 31 Cal. App. 4th 166, 173, 181–82 (1994); Santa Cruz, Cal., Mun. Code § 16.06.030(a), (d)(1); Santa Cruz, Cal., Mun. Code § 16.06.040(a); *see also* Tehama Cnty., Cal., Health & Safety Code §§ 9.40.040–9.40.045 (requiring wells, except domestic wells and wells that serve various types of public water systems, first operated after 1991 to limit their "radius of influence" to "the boundaries of the parcel [or contiguous parcels under the same ownership]").

62 **To prevent or slow overdraft and other negative consequences of excessive groundwater extraction, a number of counties adopted temporary moratoria on well construction or modification during the recent drought.** *See, e.g.,* Heather Hacking, *Glenn County to Resume Granting Permits for New Wells*, Chico Enterprise-Record, Aug. 3, 2016, *available at* http://www.chicoer.com/general-news/20160803/glenn-county-to-resume-granting-permits-for-new-wells; Claudia Boyd-Barrett, *Ojai Extends Ban on Private Water Wells*, Ventura Cnty. Star, Oct. 14, 2015, *available at* http://www.vcstar.com/news/local/ojai/ojai-extends-ban-on-private-water-wells-ep-1321278317-350982021.html; Brownstein Water Group, *Groundwater Regulation on the Rise as Counties Gear Up to Meet Sustainable Management Requirements*, Brownstein Hyatt Farber Schreck, Feb. 2, 2015, http://water.bhfs.com/groundwater-regulation-on-the-rise-as-counties-gear-up-to-meet-sustainable-management-requirements/.

63 **Already wary of potential negative impacts from groundwater exports (starkly illustrated in the well-known example of Owens Valley), many counties adopted ordinances requiring permits for groundwater exports in the late 1990s, as state and federal support for water transfers, as well as the amount of water traded, grew.** *See* Ellen Hanak, Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water Market 42–44 (2003) [hereinafter Hanak 2003], *available at* http://web.ppic.org/content/pubs/report/R_703EHR.pdf; Ellen Hanak & Elizabeth Stryjewski, California's Water Market, By the Numbers: Update 2012, at 15–16, 19 fig.3 (2012), *available at* http://www.ppic.org/content/pubs/report/R_1112EHR.pdf; *see also* Gregory S. Weber, *Twenty Years of Local Groundwater Export Legislation in California: Lessons from a Patchwork Quilt*, 34 Natural Resources J. 657, 662 n.25 (1994). **For example, many of the counties north of the Sacramento-San Joaquin River Delta require permits to extract groundwater for export, including Shasta County, Butte County, Colusa County, Yolo County, and Sacramento County.** *See* Transfer History, *supra* note 57, at 9 tbl.1; *See* Bulletin 118, Update 2003, *supra* note 36, at 36–39; *see also* Cal. Water Code § 1220. **Some include exceptions, for example for commercial water-bottling operations.** *See, e.g.*, Sarah Kirby, *Groundwater Sales Initiative Gathers Over 2,000 Signatures in Ballot Bid*, Siskiyou Daily News, June, 18, 2016, http://www.siskiyoudaily.com/article/20160618/NEWS/160619742; Siskiyou Cnty., Cal., Code § 3-13.301. **Most of these ordinances limit not only direct groundwater exports but also indirect exports from groundwater-substitution-based transfers of surface water.** Hanak & Stryjewski, *supra* this note, at 16; *see* Hanak 2003, *supra* this note, at 49–50; Bulletin 118, Update 2003, *supra* note 36, at 39 tbl.4. **Researchers have suggested that, instead of "encouraging a process of review and proper mitigation of transfers," export permitting ordinances "appear to have worked principally to discourage groundwater-related transfers altogether from these counties," because the environmental review process required under CEQA can introduce substantial up-front costs, there is a possibility of rejection, and granted permits are time limited.** Hanak & Stryjewski, *supra* this note, at 17; Hanak 2003, *supra* note 63, at 60–62.

64 **Some ordinances also require permits for off-parcel groundwater use. Tehama County's ordinance requires a permit for off-parcel groundwater use.** *See* Tehama Cnty., Cal., Health & Safety Code §§ 9.40.030–9.40.080; *Baldwin v. Cnty. of Tehama*, 31 Cal. App. 4th 166, 171–72 (1994) (stating that Tehama's ordinance (1) requires a permit "to extract groundwater for the purpose of use on land other than where the extraction occurs," (2) allows a permit to be granted only upon a finding that such use will not result in certain adverse impacts or effectively constitute groundwater mining, and (3) prohibits wells from being operated in a way that causes "a cone of depression in the water table beyond the boundaries of the property"); *see also* Transfer History, *supra* note 57, at 9 tbl.1; *See* Hanak 2003, *supra* note 63, at 48–49, 60 (noting that the sole permit granted in Tehama County under the ordinance "was for the movement of a small quantity of groundwater to land owned by the same farmer in another county"). **Some ordinances require permits for non-local parties to participate in groundwater banking.** Hanak & Stryjewski, *supra* note 63, at 16.

65 **Under the common law Public Trust Doctrine, the State of California holds all navigable waterways and non-navigable streams that sustain a fishery in trust for the benefit of the public.** *See Nat'l Audubon Soc'y v. Superior Court*, 33 Cal. 3d 419, 445 (1983); *Cal. Trout, Inc. v. State Water Resources Control Bd.*, 207 Cal.App.3d 585, 630 (1989). **Public trust uses include fishing, boating, and preserving navigable waterways in their natural state and as environments that support fish and other wildlife.** *See Marks v. Whitney*, 6 Cal. 3d 251, 259–60 (1971). **The doctrine imposes a duty on state courts and agencies "to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible" as well as to exercise "continuing supervision over the taking and use" of water.** 33 Cal. 3d at 443, 446–447 (explaining that "[a]ll uses of water, including public trust uses, must . . . conform to the standard of reasonable use"). **If past allocation decisions turn out to be "incorrect in light of current knowledge or inconsistent with current needs," the state can reconsider them.** *Id.* at 447 (holding that "[n]o vested rights bar such reconsideration"). **Although the California Supreme Court has not spoken directly to the issue, a Superior Court concluded that the Public Trust Doctrine similarly "protects navigable waterways from harm caused by groundwater extraction."** *See Envtl. L. Found. v. State Water Resources Control Bd.*, 2014 WL 8843074, at 2 (Cal. Super. Ct. 2014). **This holding appears consistent with Supreme Court precedent that the doctrine "protects navigable waters from harm caused by diversion of nonnavigable tributaries."** 33 Cal. 3d at 437; *see also Envtl. L. Found.,* 2014 WL 8843074, at 2. **Because groundwater itself is not navigable, the doctrine has been held to "have no direct application to groundwater resources."** *Santa Teresa Citizen Action Group v. City of San Jose*, 114 Cal.App.4th 689, 709 (2003). **To minimize legal vulnerability, a GSA's transfer program should be consistent with the Public Trust Doctrine. In other words, the program should be designed to minimize harm to public trust uses of navigable waterways whenever feasible. This essentially represents a subset of SGMA's requirement to avoid significant and unreasonable adverse impacts to beneficial uses of surface water, which encompasses all surface water and all beneficial uses.** *See* Cal. Water Code § 10721(x)(6).

66 Cal. Water Code, §§ 13000–16104.

67 33 U.S.C. §§ 1251–1388.

68 42 U.S.C. §§ 300f–300j-26.

69 **The federal Endangered Species Act prohibits any person from "taking" an endangered animal species, where "take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."** *See* 16 U.S.C. §§ 1538(a)(1)(B); 16 U.S.C. § 1532(19); *see also* 50 C.F.R. § 17.3 (defining "harm" to "include significant habitat modification

or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering"). **An "endangered species" is one "in danger of extinction throughout all or a significant portion of its range," while a "threatened species" is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."** 16 U.S.C. § 1532(6), (20). **Endangered or threatened species listings and critical habitat designations must be based on "the best scientific and commercial data available."** *Id.* § 1533(b)(1)(A), (2). **Critical habitat includes "specific areas within the geographic area occupied by the species, at the time it is listed" with physical or biological features that are "essential to the conservation of the species and . . . may require special management considerations or protection" and "specific areas" not occupied at the time of listing if determined to be "essential for the conservation of the species."** *Id.* § 1532(5). **Incidental take can be authorized by permit if the applicant submits and demonstrates the ability to implement an adequate conservation plan and "the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild."** *See id.* § 1539(a)(1)(B), (a)(2). **In general, the take prohibition does not apply to species for which there is a cooperative agreement with a state that maintains an adequate conservation program.** *See id.* § 1535(g)(2). **Furthermore, federal agencies must consult with the U.S. Fish and Wildlife Service or National Marine Fisheries Service to ensure that agency actions, including permitting decisions, are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical] habitat."** *See id.* § 1536(a)(2). **The wildlife agency must produce a biological opinion and, if it jeopardy or adverse modification of critical habitat will not result, an incidental take statement that specifying how incidental take will affect the species and what "reasonable and prudent measures" are needed to minimize the impact and associated terms and conditions.** *Id.* § 1536(b)(3)(A), (b)(4); 50 C.F.R. § 402.14(g)–(i).

70 **California's Endangered Species Act includes many similar provisions to the federal Act.** *See generally* Cal. Fish & Game Code §§ 2050–2115.5.

71 **For example, in 2014 and 2015, the SWRCB adopted emergency regulations that required curtailments of water diversions to maintain "minimum flows for migration of State and federally listed anadromous fish" with exceptions for "minimum health and safety needs."** *See Curtailment of Diversions Due to Insufficient Flow for Specific Fisheries*, State Water Resources Control Bd., http://www.swrcb.ca.gov/waterrights/water_issues/programs/drought/mill_deer_antelope_creeks.shtml (last updated Nov. 2, 2015); *see also Current Curtailment of Diversions in Mill, Deer, and Antelope Creeks*, State Water Resources Control Bd.., http://www.swrcb.ca.gov/waterrights/water_issues/programs/drought/milldeerantelope_curtailment_info.shtml (last updated Mar. 15, 2016). **Similarly, the SWRCB adopted emergency regulations in 2015 to protect fish in tributaries to the Russian River.** *See State Water Board Drought Year Water Actions - Russian River*, State Water Resources Control Bd., http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/water_action_russianriver.shtml (last updated Jul. 18, 2016). **The SWRCB also has a Policy for Maintaining Instream Flows in Northern California Coastal Streams that applies to water right applications, petitions, and registrations.** *See* State Water Resources Control Bd., Policy for Maintaining Instream Flows in Northern California Coastal Streams, (2014), *available at* http://www.waterboards.ca.gov/waterrights/water_issues/programs/instream_flows/docs/adopted_policy.pdf. **The SWRCB is working on potential changes to San Joaquin River flow objectives that would require more water for salmon.** *See Draft Revised Substitute Environmental Document in Support of Potential Changes to the Water Quality Control Plan for the Bay-Delta: San Joaquin River Flows and Southern Delta Water Quality*, State Water Resources Control Bd., http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2016_sed/index.shtml (last updated Sept. 26, 2016). **The California Department of Fish and Wildlife develops recommendations for instream flow standards and submits them to the SWRCB for consideration.** *See CDFW Instream Flow Recommendation Map*, Cal. Dep't of Fish & Wildlife, https://www.wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Recommendations (last visited Oct. 6, 2016); *see also* Cal. Pub. Res. Code §§ 10001–04; Cal. Water Code § 1257.5.

72 *See* Cal. Water Code § 10727.4(l); Cal. Code Regs. tit. 23, § 354.16(g) (requiring GSAs to identify groundwater dependent ecosystems).

73 **CEQA requires state and local agencies to evaluate the environmental impacts of proposed projects over which they have discretionary approval power and to mitigate or avoid significant effects whenever feasible.** *See* Cal. Pub. Res. Code §§ 21002, 21002.1; *see also id*. § 21061.1 (defining "feasible"); *id.* § 21065 (defining "project"). **An environmental impact report must be prepared and considered for any project that an agency intends "to carry out or approve which may have a significant effect on the environment."** *See id.* § 21151 (regarding local agencies); *see also id.* § 21100(a) (regarding state agencies). **Local agencies must examine "substantial, or potentially substantial, adverse changes in physical conditions which exist within the area" that will be affected by the proposed project.** *Id.* §§ 21151(b), 21060.5. **The report is meant to provide the public and public agencies with information about the likely effects of a proposed project, how the significant negative impacts can be minimized, and potential alternatives to the project.** *Id.* §§ 21002.1(a), 21061. **Preparation of an environmental impact report is not required for proposed projects that will not have significant environmental effects, or for which project plan revisions agreed to by the applicant would avoid any significant effects**. *See id.* § 21064 (regarding negative declarations); *id.* § 21064.5 (regarding mitigated negative declarations). **Although SGMA exempts groundwater sustainability planning from CEQA compliance, it does not exempt "project[s] that would implement actions taken pursuant to a plan."** *See* Cal. Water Code § 10728.6; *see also* Cal. Pub. Res. Code §§ 21000–21189.3 (Division 13). **Therefore, a GSA proposing to establish a transfer program or to authorize individual groundwater transfers would need to analyze the potential environmental impacts of these actions.** *See* Cal. Pub. Res. Code § 21065 (defining a "project" subject to CEQA analysis as "an activity which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment, and which is any of the following: (a) An activity directly undertaken by any public agency. (b) An activity undertaken by a person which is supported, in whole or in part, through contracts, grants, subsidies, loans, or other forms of assistance from one or more public agencies. (c) An activity that involves the issuance to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies").

74 *See, e.g.,* Andreas Charalambous, Transferable Groundwater Rights: Integrating Hydrogeology, Law, and Economics 92–93, 106, 117–18, 156–57 (2013) (describing limited groundwater trading in Chile, Mexico, Australia, England, and Wales); *see also generally* Nicholas Brozović & Richael Young, *Design and Implementation of Markets for Groundwater Pumping Rights*, *in* Water Markets for the 21st Century: What Have We Learned?, at 283 (K. William Easter & Qiuqiong Huang eds., 2014); Marcus Moench et al., Groundwater Governance: A Global Framework for Country Action: Thematic Paper 7: Trends in Local Groundwater Management Institutions 16–19 (2013), *available at* http://www.groundwatergovernance.org/fileadmin/user_upload/groundwatergovernance/docs/Thematic_papers/GWG_Thematic_Paper_7.pdf (describing informal and formal markets); Lijuan Zhang et al., *Development of Groundwater Markets in China: A Glimpse into Progress to Date,* 36 World Dev. 706 (2008); Slim Zekri & Ahmed Salim Al-Marshudi, *A Millenarian Water Rights System and Water Markets in Oman*, 33 Water Int'l 350 (2008).

75 *See, e.g.,* Brozović & Young, *supra* note 74, at 283, 294–97 (discussing Arizona, California, Kansas, Nebraska, and Texas); Charalambous, *supra* note 74, at 130 (mentioning trading, sometimes associated with groundwater banking, in Idaho, Nevada, Texas, Oregon, and California); Sarah Ann Wheeler et al., *Lesson to Be Learned from Groundwater Trading in Australia and the United States*, *in* Integrated Groundwater Management, at 493, 509–12 (A.J. Jakeman et al. eds., 2016) (discussing Nebraska and Texas); Bonnie G. Colby, *Cap-and-Trade Policy Challenges: A Tale of Three Markets*, 4 Land Econ. 638, 642–45 (2000) (discussing Texas).

76 *See, e.g.,* Central Basin Watermaster Administrative Body, Water Rights Panel, Watermaster Service in the Central Basin – Los Angeles County, July 1, 2013 – June 30, 2014, at 4–5 (2014), *available at* http://www.cbwatermaster.org/assets/2014_cb_watermaster_report_6.pdf (describing 9 sales, totaling 890 acre-feet, and 55 leases, totaling 26,973 acre-feet during the 2013–14 fiscal year; noting that permanent sales of Allowed Pumping Allocations have reduced the number of parties subject to the Central Basin adjudication from 508 to 131 between 1966–67 and 2013–14).

77 *See* Cal. Dep't Water Resources & U.S. Bureau Reclamation, Draft Technical Information for Preparing Water Transfer Proposals: Information for Parties Preparing Proposals for Water Transfers Requiring Department of Water Resources or Bureau of Reclamation Approval 23 (2016) [hereinafter 2016 Water Transfers White Paper], *available at* http://www.water.ca.gov/watertransfers/docs/2016_Water_Transfer_White_Paper.pdf.

78 Cal. Water Code § 1745.10. **"[I]f a groundwater management plan has not been adopted," the water supplier must "determine[] that the transfer will not create, or contribute to, conditions of long-term overdraft in the affected groundwater basin."** *Id.* § 1745.10(b).

79 *See* Cal. Dep't Water Resources, California's 1987–92 Drought 27– 29 (1993), *available at* http://www.water.ca.gov/waterconditions/docs/2_drought-1987-92.pdf.

80 *See* Brian E. Gray, *The Market and the Community: Lessons from California's Drought Water Bank*, 1 Hastings W.–Nw. J. Envtl. L. & Pol'y 17, 36–37 (1994) (stating that "[t]he strongest criticism of the Water Bank [wa]s the claim . . . that the Department of Water Resources did not adequately evaluate the effects of the groundwater substitution transfers on the groundwater resources of Yolo County," including "overdraft of the aquifer and subsidence in adjacent areas").

81 *See* Cal. Water Code § 1745.11. Note that recharge may be indirectly accomplished through the delivery of imported water in lieu of exercising groundwater rights.

82 *See supra* note 4 and accompanying text.

83 *See, e.g.*, Mike Young & Bryce McAteer, Sharing Groundwater: A Robust Framework and Implementation Roadmap for Sustainable Groundwater Management in California 11, 19 (2017), *available at* https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_17-02.pdf; James H. Skurray & David J. Pannell, *Potential Approaches to the Management of Third-Party Impacts from Groundwater Transfers*, 20 Hydrogeology J. 879, 879 (2012); David Aladjem & David Sunding, *Marketing the Sustainable Groundwater Management Act: Applying Economics to Solve California's Groundwater Problems*, Natural Resources & Env't, Fall 2015, at 1, 2 (citing Elinor Ostrom's work); James Shortle, *Economics and Environmental Markets: Lessons from Water-Quality Trading*, 42 Agric. & Econ. Rev. 57, 57, 66 (2013). **As Elinor Ostrom has noted, "[i]nstitutions are rarely either private or public — 'the market' or 'the state'"; "[n]o market can exist for long without underlying public institutions to support it," such that "[i]n field settings, public and private institutions frequently are intermeshed and depend on one another, rather than existing in isolated worlds."** Elinor Ostrom, Governing the Commons: The Evolution of Institutions for Collective Action 14–15 (1990).

84 *See* U.S. Geological Survey, What is Ground Water? Open-File Report 93-643, at 1 (1993, reprinted 2001), *available at* http://pubs.usgs.gov/of/1993/ofr93-643/pdf/ofr93-643.pdf.

85 *See* Skurray et al. 2012, *supra* note 4, at 261; Nicholas Brozović et al., *On the Spatial Nature of the Groundwater Pumping Externality*, 32 Resource & Energy Econ. 154, 162 (2010).

86 Zack Donohew, Markets and Private Property Rights to Groundwater 6 (2013), *available at* http://www.leadingwithconservation.org/wp-content/uploads/2013/07/clc-donohew_05.pdf.

87 Tom Tietenberg & Lynne Lewis, Environmental & Natural Resource Economics 38 (9th ed. 2012); Bonnie Colby Saliba, *Do Water Markets "Work"? Market Transfers and Trade-Offs in the Southwestern States*, 23 Water Resources Res. 1113, 1120–21 (1987) (stating that "[t]he heart of equity concerns about markets lies in the tension between individual and collective interests": "[m]arket decisions, by their very nature, involve atomistic individuals making choices in their own best interest and they do not readily accommodate collective preferences").

88 Laura Brock Marbury & Melinda Taylor, Myths and Facts About Groundwater Marketing: A Guide for Landowners and Groundwater Conservation Districts 7 (2007); *see also* Harrison C. Dunning, *Reflections on the Transfer of Water Rights*, 4 J. Contemporary L. 109, 110 (1977).

89 *See, e.g.*, Skurray & Pannell, *supra* note 83, at 881 (explaining that "[c]osts or benefits imposed on participants in an activity or transaction are referred to as 'private' costs and benefits," while "[c]osts or benefits imposed on parties other than those directly involved are referred to as 'external' costs or benefits, or 'externalities'"); Tietenberg & Lewis 2012, *supra* note 87, at 25 ("An *externality* exists whenever the welfare of some agent, either a firm or household, depends not only on his or her activities, but also on activities under the control of some other agent." (emphasis in original)); Ronald C. Griffin, Water Resource Economics: The Analysis of Scarcity, Policies, and Projects 147–48 (2d ed. 2016) (explaining that "[a]n externality occurs when a 'third' agent's utility or production function contains items . . . that are chosen by one or more other agents without regard for the third agent's welfare" and describing "the common situation in which market bargains struck between two agents affect third parties in an economically inefficient way"); Charles W. Howe et al., *Innovative Approaches to Water Allocation: The Potential for Water Markets*, 22 Water Resources Res. 439, 441 (1986).

90 *See* Kirsten Rudestam et al., *"The Commons" as a Dynamic Variable in Understanding Strategic Alliances of Scale: A Groundwater Case Study in Pajaro Valley, California*, 52 Envtl. Sci. & Policy 33, 33–34 (2015); Borchers et al., *supra* note 1, at ES-1; Encarna Esteban

& José Albiac, *The Problem of Sustainable Groundwater Management: The Case of La Manch Aquifers, Spain*, 20 Hydrogeology J. 851, 852 (2012) (noting that "[g]roundwater externalities can be classified considering different dimensions such as contemporary or intertemporal externalities, groundwater quantity or quality externalities, and economic or environmental externalities"); *see also generally* Bill Provencher & Oscar Burt, *The Externalities Associated with the Common Property Exploitation of Groundwater*, 24 J. Envtl. Econ. Mgmt. 139 (1993) (discussing "the pumping cost externality," "the stock externality," and "the risk externality"); Victor Brajer & Wade E. Martin, *Allocating a 'Scarce' Resource, Water in the West: More Market-like Incentives Can Extend Supply, but Constraints Demand Equitable Policies*, 48 Am. J. of Econ. & Sociology 266–67 (1989) (mentioning "increased pumping costs due to falling water levels and well interference," land subsidence, seawater intrusion, and other water quality degradation).

91 **SGMA was passed as three related bills known as S.B. 1168, A.B. 1739, and S.B. 1319.** *See* 2014 Cal. Legis. Serv. ch. 346 ["S.B.1168"]; 2014 Cal. Legis. Serv. ch. 347 ["A.B. 1739"]; 2014 Cal. Legis. Serv. ch. 348 ["S.B. 1319"]. **It went into effect January 1, 2015. A set of four bills—S.B. 13, A.B. 617, A.B. 939, and S.B. 226—passed in 2015 subsequently cleaned up or clarified SGMA language and addressed the interaction of SGMA with new and ongoing groundwater adjudication actions.** *See* 2015 Cal. Legis. Serv. ch. 255 ["S.B. 13"]; 2015 Cal. Legis. Serv. ch. 666 ["A.B. 617"]; 2015 Cal. Legis. Serv. ch. 667 ["A.B. 939"]; 2015 Cal. Legis. Serv. ch. 676 ["S.B. 226"]. **Also in 2015, separate legislation established procedures for comprehensive groundwater adjudication in superior court.** *See* 2015 Cal. Legis. Serv. ch. 672 ["A.B. 1390"].

92 *See* Hanak 2003, *supra* note 63, at vii.

93 *See, e.g.*, S. Wheeler et al., *Reviewing the Adoption and Impact of Water Markets in the Murray-Darling Basin, Australia*, 518 J. Hydrology 28, 35–38 (2014); Wheeler et al. 2016, *supra* note 75, at 498–99, 502–03 (mentioning increased pumping costs, reduction in storage and groundwater levels, and surface water impacts); Tamara Boyd & John Brumley, *Optimising Sustainable Use of Groundwater: A Challenge for Science and Water Markets*, at 9, 1st International Conference on Sustainability Engineering and Science, Auckland, July 6–9, 2004, *available at* http://www.thesustainabilitysociety.org.nz/conference/2004/Session5/04%20Brumley-Boyd.pdf (describing concentration of extraction after 4 years of trading, producing a large cone of depression in the area); Joseph L Sax, *Understanding Transfers: Community Rights and the Privatization of Water*, 1 West-Northwest 13, 15 (1994) (discussing the issue of wealth redistribution); Brajer & Martin, *supra* note 90, at 266–68 (discussing externalities and concluding that "the existence of hydrologic uncertainty and potentially significant external costs (particularly in the case of groundwater) may hamper the attainment of a socially efficient allocation of water resources").

94 Boyd & Brumley, *supra* note 93, at 9; Wheeler et al. 2016, *supra* note 75, at 502–03.

95 *See* Pamela Giselle Katic, *Groundwater Spatial Dynamics and Endogenous Well Location*, 29 Water Resources Mgmt. 181, 182 (2014) (stating that, "[d]espite the vast economic literature on groundwater extraction, no [previous] theoretical models have incorporated spatial choice variables and quantitatively evaluated the effect of different groundwater representations on economic results"); Nicholas Brozović et al., *supra* note 85, at 162 (noting that "[m]ost economic analyses of optimal groundwater management use single-cell aquifer models, which assume that an aquifer responds uniformly and instantly to groundwater pumping"; concluding that such "single-cell models may significantly understate the magnitude and spatial nature of the groundwater externality" under some circumstances); Brajer & Martin, *supra* note 90, at 268 ("While empirical economic studies have demonstrated a variety of results, and perhaps more importantly the extreme sensitivity of these results to various hydrologic and economic parameters, most of the studies have used very simple approaches to modeling the aquifers and the movement of water within them. Such models assume hydrologic uniformity and do not adequately account for the different conditions faced by irrigators in different parts of a basin. Without meaningful hydrologic data and realistic modeling representations of the involved aquifers, any results obtained must be viewed somewhat tentatively. It seems clear that given the potential magnitude of this externality issue, more work needs to be done in the area where hydrology and economics are inextricably interconnected to produce any meaningful social policy recommendations." (internal citation omitted)).

96 *See* Wheeler et al. 2016, *supra* note 75, at 498–99 (arguing that "[r]egulation is needed" because "[g]roundwater is not used optimally by individuals who do not internalize . . . extraction costs and environmental externalities in their pumping decisions," "a significant reason for market failure [that] highlights the need for institutional arrangements."); *see also* Griffin, *supra* note 89, at 145, 152 (stating that "calls for so-called free markets in water are normally too superficial to have merit" and that, "[o]ften, a mixed institutional system will be preferred, using market-oriented institutions where possible to harness private incentives, but leaning on nonmarket institutions where the prospect of market failure [due, e.g., to significant externalities] is worrisome"); Esteban & Albiac, *supra* note 90, at 861–62 (suggesting that, "when environmental damage is taken into account, regulation policies correct the market failure and achieve considerable welfare gains").

97 *See, e.g.*, Skurray & Pannell, *supra* note 83, at 886 (describing the possibility of establishing "sell-only" zones around groundwater dependent ecosystems that move extraction away from these sensitive areas); Aladjem & Sunding, *supra* note 83, at 3 (concluding that "well-functioning markets within groundwater basins can also help address the externalities between basins or between GSAs").

98 Brozović & Young, *supra* note 74, at 283, 284, 286–289 ("Under conditions where groundwater pumping is constrained, monitored, and enforced, allowing water users to trade pumping rights is a cost-effective mechanism to reduce the costs of regulations on water users."); *see also* Wheeler et al., *supra* note 93, at 36 ("Despite the early reluctant acceptance of water trading, there is now a clear under- standing within the irrigation community that without water trading the socio-economic impact of the current drought would have been much harsher.").

99 *See* Wheeler et al. 2016, *supra* note 75, at 496, 512–14.

100 *See e.g.*, Aladjem & Sunding, *supra* note 83, at 3 ("Accurate monitoring and measurement of groundwater use is a precondition for the establishment of a market."); Brozović & Young, *supra* note 74, at 283, 286; James Skurray, *The Scope for Collective Action in a Large Groundwater Basin: An Institutional Analysis of Aquifer Governance in Western Australia*, 114 Ecological Econ. 128, 138 (2015) (finding "inadequate metering, and lax enforcement, to be the source of a range of difficulties in Gnangara groundwater governance").

101 *See* Alvar Escriva-Bou et al., Accounting for California's Water 16 (2016) [hereinafter Escriva-Bou et al. Report], *available at* http://www.ppic.org/content/pubs/report/R_716EHR.pdf. **"[O]nly urban utilities and a few local irrigation districts have measured use at the parcel level."** Alvar Escriva-Bou et al., Accounting for California's Water — Technical Appendix 27 (2016) [hereinafter Escriva-Bou et al. Appendix], *available at* http://www.ppic.org/content/pubs/other/716EHR_appendix.pdf.

102 *See* Escriva-Bou et al. Report, *supra* note 101, at 16; Lori Pottinger, *The Challenges of Getting More Crop Per Drop*, Pub. Pol'y Inst. Cal. Blog, July 28, 2015, http://www.ppic.org/main/blog_detail.asp?i=1826.

103 Rules and Regulations of the Mojave Basin Area Watermaster, § 11 (revised Oct. 29, 2008), *available at* https://www.mojavewater.org/files/Rules.pdf. **Similarly, all parties to the Antelope Valley adjudication, except those in the "Small Pumper Class," were required to install well meters within 2 years.** *Antelope Valley Groundwater Cases*, Case No. 1-05-CV-049053, at 30 (Cal. Super. Ct. Dec. 23, 2015) (Judgment and Physical Solution for Coordinated Proceeding No. 4408).

104 *See* Fox Canyon Groundwater Mgmt. Agency, Annual Report for Calendar Year 2015, at 21 (2017) [hereinafter Fox Canyon 2015 Annual Report], *available at* http://www.fcgma.org/public-documents/reports; Fox Canyon Groundwater Mgmt. Agency, Cal., Ordinance Code §§ 2.3, 3.1.

105 *See* Cal. Water Code § 4999–5002; *see also* Cal. Code. Regs. tit. 23, § 930. Someone who fails to file a notice cannot claim a prescriptive right accrued during that time. *See* Cal. Water Code § 5003.

106 *See* Cal. Water Code § 10725.8; *see also id.* § 10721(e) (defining de minimis extractors); *see also* Young & McAteer, *supra* note 83, at 25–26 (arguing that, "[i]n practice, it is likely to be more cost effective to require counties and cities to offset the impact of estimated domestic groundwater well use on an aquifer than to issue shares to and meter each domestic well" and that pumping for livestock uses of "one acre-foot per annum . . . be allowed to continue and be ignored until a basin authority considers that the cost of accounting for them is less than the benefit to all others of doing so").

107 *See* Cal. Water Code § 10726.4(a)(3).

108 *Id.* § 10721(w).

109 *See* Cal. Code Regs. tit. 23, § 354.26 (noting that a GSA "may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin" and that "[t]he determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site"). **Note that "a groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015."** Cal. Water Code § 10727.2(b)(4)

110 *See* Cal. Code Regs. tit. 23, § 351(t) (defining a "minimum threshold" as "a numeric value for each sustainability indicator used to define undesirable results"); *id.* § 354.28.

111 *See id.* § 351(s) (defining a "measurable objectives" as "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin."); *id.* § 354.30.

112 *See id.* § 351(ah) (defining sustainability indicator as "any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results"); Cal. Water Code § 10721(x) (defining the six undesirable results).

113 Cal. Water Code §§ 10727.2(b)(1), 10721(u).

114 Juliet Christian-Smith & Kristyn Abhold, Union of Concerned Scientists, Measuring What Matters: Setting Measurable Objectives to Achieve Sustainable Groundwater Management in California 6 (2015), *available at* http://www.ucsusa.org/global-warming/regional-information/california-and-western-states/measuring-what-matters#.V3ZZu5ODFBc.

115 *See id.* at 20–21, 21 fig.4.

116 *See* Cal. Code Regs. tit. 23, §§ 352.4(f), 354.18(f), 354.18(e), (f), 354.26(b)(1), 354.28(b)(1), (c)(6); Cal. Dep't Water Resources , Best Management Practices for the Sustainable Management of Groundwater: Modeling BMP 8 (2016) [hereinafter Modeling BMP], *available at* http://www.water.ca.gov/groundwater/sgm/pdfs/BMP_Modeling_Final_2016-12-23.pdf (noting that "the use of models for developing a GSP is highly recommended, but not required" and that GSAs must "carefully consider if changing basin conditions and proposed projects and management actions have the potential to trigger undesirable results within the basin or in adjacent basins, and whether a model is necessary to demonstrate that the proposed projects and management actions will achieve the sustainability goal"). **Models must "include publicly available supporting documentation," must "be based on field or laboratory measurements, or equivalent methods that justify the selected values, and calibrated against site-specific field data," and, if developed after August 15, 2016, must "consist of public domain open-source software."** Cal. Code Regs. tit. 23, § 354.18(f).

117 *See* Tara Moran, Projecting Forward: A Framework for Groundwater Model Development Under the Sustainable Groundwater Management Act 9 (2016), *available at* http://waterinthewest.stanford.edu/sites/default/files/Groundwater-Model-Report.pdf ("[I]f a basin establishes a minimum threshold for groundwater levels in the basin, a model can help convert that threshold into the amount of groundwater pumping that can be sustained or the amount of artificial recharge needed to ensure the basin does not drop below the established threshold.").

118 Cal. Code Regs. tit. 23, § 354.14.

119 *See id.* §§ 352.4(f), 354.14, 354.18(f), 354.18(e), (f), 354.26(b)(1), 354.28(b)(1), (c)(6).

120 *See generally* Cal. Dep't Water Resources , Best Management Practices for the Sustainable Management of Groundwater: Hydrogeologic Conceptual Model BMP (2016), *available at* http://www.water.ca.gov/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf; Modeling BMP, *supra* note 116.

121 *See generally* Moran, *supra* note 117.

122 *See* Modeling BMP, *supra* note 116, at 4, 8 (describing analytical models as "most suited to initial scoping studies or basins with simple hydrologic conditions or easily idealized basins" and noting that "simple models may overlook important system components and the interconnectedness of undesirable results, and may be difficult to calibrate to historical data").

123 *See id.* at 4, 8 (explaining that "GSPs developed for complex basins with significant groundwater withdrawals and/or surface water - groundwater interaction may require the use of a numerical groundwater - surface water model to demonstrate that the GSP will avoid undesirable results and achieve the sustainability goal within the basin" and suggesting that GSAs "build the simplest model that honors all

relevant available data and knowledge, while providing a reasonable modeling tool to achieve the desired decision support at a desirable level of certainty").

124 *See* Moran, *supra* note 117, at 19, box 4.

125 **DWR's GSP regulations explicitly reference the option of creating management areas.** *See* Cal. Code Regs. tit. 23, § 351(r) (defining "management area" as "an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors"); *Id.* tit. 23, § 354.20 (providing that a GSA "may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan" and that "[m]anagement areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin").

126 *See generally* Kiparsky et al., *supra* note 44.

127 *See* Skurray et al. 2012, *supra* note 4, at 263.

128 *See* Cal. Water Code § 10721(y).

129 Bulletin 118, Update 2003, *supra* note 36, at 106.

130 *See infra* note 335 and accompanying text.

131 *See infra* note 336 and accompanying text.

132 *See* Escriva-Bou et al. Report, *supra* note 101, at 11.

133 *See* Kearns & West, Inc., & HydroMetrics, Inc., Assessment of Stakeholder Perspectives: Options for Implementing the Sustainable Groundwater Management Act in Butte County 17 (May 2, 2016), https://www.buttecounty.net/wrcdocs/planning/SGWMA/GWAssess/SGMAAssessFinalRpt.pdf.

134 *See* Cal. Water Code § 10726.4(a)(2), (3).

135 *Cf.* Young & McAteer, *supra* note 83, at 28 (describing similar steps in the process of allocating groundwater extraction "shares").

136 *See, e.g.*, Donohew, *supra* note 86, at 7; Young & McAteer, *supra* note 83, at 29 (describing some "sharing formulas" for agricultural land based on "recent use," water-use efficiency, and/or land area). **For example, in 2015, Fox Canyon Groundwater Management Agency, one of 17 groundwater management agencies established through a special act of the legislature,** *see* Cal. Water Code § 10723(c)(1)(D), **used four different groundwater allocation methods.** Fox Canyon 2015 Annual Report, *supra* note 104, at 10. **Domestic users received either adjusted Historical Allocations (based on average usage from 1985–89) or Baseline Allocations of 1 acre-foot per acre; municipal and industrial users received Temporary Extraction Allocations (based on average usage from 2003–12); and agricultural users received "Efficiency Allocation[s] utilizing an Irrigation Allowance Index."** *Id.* at 10–11; Fox Canyon Groundwater Mgmt. Agency, Cal., Ordinance Code §§ 1.24, 5.1–5.2, 5.4–5.6; Fox Canyon Groundwater Mgmt. Agency, Cal., Emergency Ordinance E, art. 2 (adopted April 11, 2014), [hereinafter ordinance e] *available at* http://www.fcgma.org/images/ordinances_legislation/Emergency_Ordinance_E_-_Orig._Signed_optimizer2.pdf.

137 *See* Water Commission Act of 1913, 1913 Cal. Stat. 1012; *see also Cal. Farm Bureau Fed'n v. State Water Resources Control Bd.*, 51 Cal. 4th 421, 428–29 (2011), as *modified* (Apr. 20, 2011). **Note that surface water rights include rights to water in so-called "subterranean streams flowing through known and definite channels," which are largely legal creations instead of true hydrogeologic features distinct from other groundwater.** *See* Joseph L. Sax, *We Don't Do Groundwater: A Morsel of California Legal History*, 6 U. Denver Water L. Rev. 269, 273 (2003); Cal. Water Code §§ 1200, 1221.

138 *See, e.g.*, *Katz v. Walkinshaw*, 141 Cal. 116, 120–21 (1903) (deciding a case filed by plaintiffs making overlying use of groundwater who alleged that the defendant's extraction for use on "a distant tract" "prevented any water from flowing through the plaintiffs' wells to their premises"); *Burr v. Maclay Rancho Water Co.*, 160 Cal. 268, 281 (1911) ("The controversy between the parties was over the question whether the defendant had the right to divert waters from lot 192 to land beyond the dike and not overlying the water-bearing strata."); *City of San Bernardino v. City of Riverside*, 186 Cal. 7, 10–11 (1921) (deciding a dispute between two cities, one overlying part of the basin and the other not, both taking groundwater for their inhabitants).

139 *See e.g.*, *City of Pasadena v. City of Alhambra*, 33 Cal. 2d 908 (1949), *cert. denied sub nom.*, *Cal.-Mich. Land & Water Co. v. City of Pasaden*a, 339 U.S. 937 (1950); *Tehachapi-Cummings Cnty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992 (1975); *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d 199 (1975), *disapproved of by City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224 (2000).

140 *See City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1240 (2000); *Tehachapi-Cummings Cnty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992, 1001 (1975); *see also* Transfer History, *supra* note 57, at 8.

141 *See* Cal. Const. art. X, § 2 (declaring that "[r]iparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses"); *see also* The Water Rights Process, State Water Resources Control Bd., http://www.waterboards.ca.gov/waterrights/board_info/water_rights_process.shtml (last visited Oct. 14, 2016).

142 *See City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1253 (2000) (stating that "overlying owners . . . have the right to pump water from the ground underneath their respective lands for use on their lands."); *Tehachapi-Cummings Cnty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992, 1000–1001 n.6 (1975) ("By analogy to riparian rights, overlying rights may be exercised 'for the purposes for which such lands are, or may be made adaptable.'" (quoting Cal. Const. art. X, § 2)); *United States v. Fallbrook Pub. Util. Dist.*, 165 F. Supp. 806, 824-825 (S.D. Cal. 1958); *City of Pasadena v. City of Alhambra*, 33 Cal. 2d 908, 925, 926 (1949) ("Generally speaking, an overlying right, analogous to that of a riparian owner in a surface stream, is the right of the owner of the land to take water from the ground underneath for use on his land within the basin or watershed; the right is based on ownership of the land and is appurtenant thereto."); *City of San Bernardino v.* City of Riverside, 186 Cal. 7, 16 (1921) ("[E]ach owner of land overlying the same general underground supply of water may take such water on his own land for any beneficial use thereon, so long as such taking works no unreasonable injury to other land overlying such waters . . . ."); *Katz v. Walkinshaw*, 141 Cal. 116, 134 (1903) ("The doctrine of reasonable use . . . limits the right of others to such amount of water as may be necessary for some useful purpose in connection with the land from which it is taken.").

143 *See City of Barstow v. Mojave Water Agency*, 5 P.3d 853, 873 (Cal. 2000), *affirming in part City of Barstow v. Mojave Water Agency*, 75 Cal. Rptr. 2d 477, 508–509 (Ct. App. 1998); *Wright v. Goleta Water Dist.*, 174 Cal. App. 3d 74, 86–87 (1985).

144 *See* Kevin M. O'Brien, *Alice in Groundwater Land: Water Supply Assessments and Subsurface Water Supplies*, 4 Golden Gate U. Envtl. L.J. 131, 141 (2010) (citing *Wright v. Goleta Water Dist.*, 174 Cal. App. 3d 74, 82 (1985), and *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1249 (2000)); *see also Antelope Valley Groundwater Cases*, 2016 WL 8235076 (Cal. Super. Ct. April 25, 2016), *3 (describing a settlement that "acknowledg[ed] that each class member was entitled to a non-allocated, correlative right as a dormant overlying owner").

145 *See* Anthony Scott & Georgina Coustalin, *The Evolution of Water Rights*, 35 Natural Resources J. 821, 830 (1995); *see also City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1253 (2000) ("The overlying right is correlative and is therefore defined in relation to other overlying water right holders in the basin."); *City of Pasadena v. City of Alhambra*, 33 Cal. 2d 908, 926 (1949) ("As between overlying owners, the rights, like those of riparians, are correlative and are referred to as belonging to all in common; each may use only his reasonable share when water is insufficient to meet the needs of all."); *City of San Bernardino v. City of Riverside*, 186 Cal. 7, 16 (1921) ("[I]f the natural supply is not sufficient for all such owners, each is entitled only to his reasonable proportion of the whole . . . ."); *Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist.*, 3 Cal. 2d 489, 525 (1935) (stating that "the quantity of water . . . required for . . . [future or prospective reasonable beneficial] uses cannot be fixed in amount until the need for such use arises"); *Tehachapi-Cummings Cty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992, 1000 (1975) (holding that "[t]he judgment must be reversed insofar as it declares that appellant is limited to pumping 308 acre-feet per year for use on its land within the basin" because "[t]he trial court erred in applying the mutual prescription doctrine articulated in *City of Pasadena v. City of Alhambra* . . . to quantify the water rights of the parties," who were overlying owners pumping water for overlying purposes, "on the basis of past use rather than current, reasonable and beneficial need").

146 *Tehachapi-Cummings Cty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992, 1001 (1975); *see also Pasadena v. Alhambra*, 33 Cal. 2d 908, 926 (1949); *Hudson v. Dailey*, 156 Cal. 617, 625 (1909); *Burr v. Maclay Rancho Water Co.*, 154 Cal. 428, 434–35 (1908); *Katz v. Walkinshaw*, 141 Cal. 116, 136–37 (1903).

147 *Tehachapi-Cummings*, 49 Cal. App. 3d at 1001; *see also* Cal. Const., art. X, § 2; *Katz*, 141 Cal. at 136.

148 *Tehachapi-Cummings*, 49 Cal. App. 3d at 1001–02 (suggesting that considerations regarding the nature of the projected use "for agriculture" might include "the area sought to be irrigated, the character of the soil, the practicability of irrigation, i.e., the expense thereof, [and] the comparative profit of the different crops which could be made of the water on the land").

149 *See City of Los Angeles v. City of San Fernando*, 14 Cal. 3d 199, 293 n.100 (1975) (stating that overlying rights "take priority over appropriative rights in that if the amounts of water devoted to overlying uses were to consume all the basin's native supply, the overlying rights would supersede any appropriative claims by any party to the basin's native ground water except insofar as the appropriative claims ripened into prescriptive rights" and that "prescriptive rights would not necessarily impair the . . . rights to ground water for new overlying uses for which the need had not yet come into existence during the prescriptive period"); *City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 926 (1949) ("Proper overlying use . . . is paramount, and the right of an appropriator, being limited to the amount of the surplus, must yield to that of the overlying owner in the event of a shortage, unless the appropriator has gained prescriptive rights through the taking of nonsurplus waters.").

150 *City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 925 (1949).

151 *See* Cal. Water Code §§ 1228.1–1229.1 (describing registration requirements, and their applicability, for small domestic use, small irrigation use, and livestock stockpond use); *id.* §§ 1375–1415 (describing permits); *see also* State Water Resources Control Bd., Division of Water Rights, Process for Water Right Licensing, *available at* http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/docs/licensing.pdf (explaining that "[t]he water right process has three phases: (a) application, (b) permit, and (c) license").

152 *See City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 925–26 (1949) ("Any water not needed for the reasonable beneficial uses of those having prior rights is excess or surplus water. In California surplus water may rightfully be appropriated on privately owned land for nonoverlying uses, such as devotion to a public use or exportation beyond the basin or watershed."); *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d 199, 277–78 (1975) ("A ground[water] basin is in a state of surplus when the amount of water being extracted from it is less than the maximum that could be withdrawn without adverse effects on the basin's long term supply. While this state of surplus exists, none of the extractions from the basin for beneficial use constitutes such an invasion of any water right as will entitle the owner of the right to injunctive, as distinct from declaratory, relief.").

153 *City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 279 (2012), *as modified on denial of reh'g* (Dec. 21, 2012); *see also City of Los Angeles v. City of San Fernando*, 14 Cal. 3d 199, 278 (1975) (explaining that the trial court defined "safe yield" as "the maximum quantity of water which can be withdrawn annually from a ground water supply under a given set of conditions without causing an undesirable result," namely "a gradual lowering of the ground water levels resulting eventually in depletion of the supply").

154 *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d 199, 277–278 (1975) (stating also that "[o]verdraft commences whenever extractions increase, or the withdrawable maximum decreases, or both, to the point where the surplus ends").

155 *See id.* at 199, 278 (1975); *see also Corona Foothill Lemon Co. v. Lillibridge*, 8 Cal. 2d 522, 526, 529, 531–32 (1937) (holding that there was no need to adjudicate the respective rights of overlying users where "[t]he gist of the charge is that the entire Corona area constitutes an underground reservoir and that there is therein no surplus water subject to appropriation" and the trial court enjoined the exportation of water from the basin upon finding that "there was no surplus water over and above the amount required to serve reasonable beneficial uses on overlying lands"); *Wright v. Goleta Water Dist.*, 174 Cal. App. 3d 74, 93 (1985).

156 *City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 926 (1949).

157 *See United States v. E. Mun. Water Dist.,* No. CV 04-8182 CBM RNBX, 2009 WL 2407688, at *55 (C.D. Cal. Aug. 4, 2009).

158 *See* M. Rhead Enion, Allocating Under Water: Reforming California's Groundwater Adjudications 13 (2013), *available at* https://law.ucla.edu/centers/environmental-law/emmett-institute-on-climate-change-and-the-environment/publications/allocating-under-water/.

159 *See* Cal. Water Code § 10720.8(a), (b).

160 Ruth Langridge et al., An Evaluation of California's Adjudicated Groundwater Basins 1 (2016), *available at* http://groundwater.ca.gov/docs/UCSC_Adjudicated_Groundwater_Basins_Report_FINAL.pdf.

161 *See supra* notes 26–27 and accompanying text.

162 *See* Cal. Water Code §§ 10737.2, 10737.8; *see also* Cal. Civ. Proc. Code §§ 830–852 (establishing new rules for comprehensive groundwater adjudications).

163 Langridge et al., *supra* note 160, at 2, 14 (noting that adjudications rarely consider water quality or account for interactions between groundwater and surface water); *see also, e.g., Hi-Desert Cty. Water Dist. v. Blue Skies Country Club, Inc.*, 23 Cal. App. 4th 1723, 1735 (1994) (noting that the trial court's judgment in the Warren Valley Basin adjudication "had as its object, not to relieve the overdraft so much as to allocate rights and plan for financing the cost of supplemental water" and "established that the parties would engage in 'controlled mining of such water in storage' until supplemental water became economically feasible" so "limiting the parties' water use to the safe yield was never the goal of the 1977 judgment"); Enion, *supra* note 158, at 1–2 (describing the settlement agreements and judgments resulting from adjudications as "sometimes overly protective of the property interests of a few large water users," "not typically impos[ing] aggressive measures to protect the basins from overdraft," and "often ignor[ing] environmental concerns, particularly water quality issues in basins" while also not leading to the "efficient exchange of allocations and water rights that one might expect of defined property rights"). *But see* Langridge et al., *supra* note 160, at 14 ("One exception was the Mojave judgment, which contained provisions for the protection of the water needs of endangered and other species and of riparian habitat in the Mojave Basin Area. It also established groundwater level standards in several key areas along the Mojave River.").

164 Langridge et al., *supra* note 160, at 2.

165 *Id.* (concluding that "[t]he Mojave Judgment is the only one to include specific environmental considerations").

166 *Id.* at 27.

167 **A comparison of the extent of adjudicated areas with Bulletin 118 basins shows varying degrees of mismatch between the two. Examples of incomplete basin coverage include the following: The Scott River Stream System adjudication covers a small part of the Scott River Valley Basin (Basin 1-05). The Santa Maria adjudication covers parts of the high priority Santa Maria basin (Basin 3-12). The Central Basin and Main San Gabriel Basin adjudications cover parts of the high-priority Coastal Plain of Los Angeles Central Subbasin (Basin 4-11.04). The Main San Gabriel Basin, Puente Basin, and Six Basins adjudications cover parts of the high-priority San Gabriel Valley Basin (Basin 4-13). The Western San Bernardino, San Jacinto, and Santa Margarita River adjudications cover parts of the high-priority San Jacinto Basin (Basin 8-5).** *See GICIMA, supra* note 42.

168 Langridge et al., *supra* note 160, at 4, 15 ("Large water users generally dominated negotiations for the physical solution, and small water users were generally not part of the final judgment."). **At least one adjudication did address disadvantaged communities. The Third Amended Judgment in the Central Basin adjudication established priority rights in groundwater storage space for disadvantaged communities; however, the program is still in development.** *Id.* at 15.

169 *Id.* 2, 22–23 (noting that "[t]he few basins that do not receive imported water were either adjudicated prior to the availability of imported water or are coastal basins with no current access to imported water.").

170 *Cent. & W. Basin Water Replenishment Dist. v. S. California Water Co.*, 109 Cal. App. 4th 891, 912, (2003), *as modified on denial of reh'g* (July 9, 2003).

171 *See supra* note 220 and accompanying text.

172 *See City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 297 (2012), *as modified on denial of reh'g* (Dec. 21, 2012).

173 *City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 926–27 (1949); *see also See City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 278 (1975) (noting that "on the commencement of overdraft there is no surplus available" and "appropriations of water in excess of surplus then invade senior basin rights, creating the element of adversity against those rights prerequisite to their owners' becoming entitled to an injunction and thus to the running of any prescriptive period against them.").

174 *See City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 926–27 (1949); *see also, e.g.*, *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1241 (2000).

175 *City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 297 (2012), *as modified on denial of reh'g* (Dec. 21, 2012); *see also City of Santa Maria v. Adam*, No. H041133, 2016 WL 3517417, at *1 (Cal. Ct. App. June 24, 2016) (holding that "[w]hen there is an overdraft or shortage, appellants, as overlying rights holders, would be awarded the full amount of their present and prospective beneficial use upon the land, less the amounts lost by prescription").

176 *City of Santa Maria v. Adam*, 248 Cal. App. 4th 504, 511 (2016), *reh'g denied* (July 18, 2016), *review denied* (Sept. 14, 2016) (also calling prescriptive rights "fixed," in contrast to overlying rights).

177 *See City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 272–77 (1975); *see also* Cal. Civ. Code § 1007.

178 Cal. Water Code § 10720.5(a).

179 *City of Pasadena v. City of Alhambra*, 33 Cal. 2d 908, 931–933 (1949) (describing self help); *see also City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 279 (2012), *as modified on denial of reh'g* (Dec. 21, 2012) ("Self help in this context requires the landowner to continue to pump nonsurplus water concurrently with the adverse users. When they do, the landowners retain their overlying rights, losing only the

amount of the prescriptive taking."); *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 293–294 (1975); *Hi–Desert County Water Dist. v. Blue Skies Country Club, Inc.*, 23 Cal. App. 4th 1723, 1731–1732 (1994) (stating that "overlying users retain priority but lose amounts not pumped").

180 *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 293 n.100 (1975) (noting that "prescriptive rights would not necessarily impair the private defendants' rights to ground water for new overlying uses for which the need had not yet come into existence during the prescriptive period"); *see also Tulare Irrigation. Dist. v. Lindsay-Strathmore Irrigation Dist.*, 3 Cal. 2d 489, 525–26 (1935); *Hi–Desert County Water Dist. v. Blue Skies Country Club, Inc.*, 23 Cal. App. 4th 1723, 1731–1732 (1994); *Wright v. Goleta Water Dist.*, 174 Cal. App. 3d 74, 87–88 (1985) (stating that "stare decisis and due process considerations" prevent the determination of prospective overlying rights in non-comprehensive adjudications of groundwater basins, as distinguished from comprehensive statutory adjudications of rights in surface waterways; stating that doing so "would allow prospective rights of overlying landowners to be subject to the vagaries of an individual plaintiff's pleading without adequate due process protections" despite the fact that "overlying landowners owning these present rights to future use are entitled to notice and an opportunity to resist any interference with them"). **Note that, effective January 1, 2016, the legislature established methods and procedures for comprehensive groundwater adjudications.** *See* Cal. Civ. Proc. Code §§ 833, 834, 841; 2015 Cal. Legis. Serv. ch. 672 ["A.B. 1390"]. **Presumably, comprehensive adjudications carried out under these statutory provisions could limit prospective overlying uses.**

181 *City of Santa Maria v. Adam*, No. H041133, 2016 WL 3517417, at *3–•6 (Cal. Ct. App. June 24, 2016) (declining to quantify non-stipulating overlying users' "proportionate prescriptive loss" because "[a]t the time of trial, it was undisputed that the Basin had enough water for all users, including appellants and all appropriators"; concluding that "in times of future overdraft the parties would be required to determine their proportionate, correlative share of the Basin groundwater with other overlying rights holders" and, [a]t that time, the proportionate prescriptive right that can be enforced against each of the parties would need to be quantified," emphasizing that "[s]uch need does not arise before then"; and side-stepping the question of what overlying users can do to fully protect their rights from prescription); *see also* Richard Wallace, *New Groundwater Decision Hands Water Agencies a "Win" but Leaves Unanswered Questions*, Briscoe Ivester & Bazel LLP, June 28, 2016, http://briscoelaw.net/062816-2/ (suggesting that "an outcome of the lawsuit and appeals is the adverse consequences for the non-settling plaintiffs, who fared worse than the settling landowners").

182 *See City of San Diego v. Cuyamaca Water Co.*, 209 Cal. 152, 164–65 (1930).

183 *See City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 210–11, 251 (1975).

184 *See id.* at 210–11, 252.

185 *See id*.

186 *See In re Water of Hallett Creek Stream Sys.*, 44 Cal. 3d 448, 458–61 (1988).

187 *Cappaert v. United States*, 426 U.S. 128, 139, 147 (1976).

188 *Id.* at 145.

189 *In re Water of Hallett Creek Stream Sys.*, 44 Cal. 3d 448, 457 (1988) (citing *Cappaert v. United States*, 426 U.S. 128, 138 (1976)).

190 *See supra* note 65 and accompanying text.

191 *See Cappaert v. United States*, 426 U.S. 128, 140–43 (1976). **The Court concluded that the Presidential Proclamation making Devil's Hole and surrounding lands part of Death Valley National Monument in 1952 in order to give the surface water pool in Devil's Hole and the endangered Devil's Hole pupfish it contained "special protection" will be meaningfully accomplished only if water levels adequate to support the fish are maintained.** *Id.* at 137–142, *affirming United States v. Cappaert*, 508 F.2d 313, 317–18 (9th Cir. 1974) (holding that the Presidential Proclamation "implicitly reserved enough groundwater to assure preservation of the pupfish"). **Groundwater pumping in the area had caused the water level in the pool to drop, reducing the spawning area available for the pupfish**. *See id.* at 133–35.

192 *Agua Caliente Band of Cahuilla Indians v. Coachella Valley Water Dist.*, __ F. 3d __, 2017 WL 894471, at *1 (9th Cir. Mar. 7, 2017).

193 *Id.* at *1, *6 (9th Cir. Mar. 7, 2017), *affirming Agua Caliente Band of Cahuilla Indians v. Coachella Valley Water Dist.*, No. EDCV 13-883-JGB, 2015 WL 1600065, at *1, *7 (C.D. Cal. Mar. 20, 2015). **This decision was reached in the first phase of litigation, which "seeks to address whether the Tribe has a reserved right and an aboriginal right to groundwater."** *Id.* at *3. **Subsequent phases will address (a) "whether the Tribe beneficially owns the "pore space" of the groundwater basin underlying the Agua Caliente Reservation and whether a tribal right to groundwater includes the right to receive water of a certain quality" and then (b) quantification of "any identified groundwater rights."** *Id.*

194 *See* Transfer History, *supra* note 57, at 11 ("From a water rights perspective, the surface water stored in a groundwater banking program is treated like water stored in a surface reservoir. It retains the water rights limitations specified under the water right, including its place of use. When water is extracted from groundwater storage, it must be used within the authorized place of use specified in the surface water permits. Just as directly diverted or stored surface water may be transferred, surface water stored in a groundwater banking facility may be transferred.").

195 *See* Juliet Christian-Smith, Improving Water Management through Groundwater Banking: Kern County and the Rosedale-Rio Bravo Water Storage District 1–2 (2013), *available at* http://pacinst.org/app/uploads/2013/02/groundwater_banking3.pdf.

196 *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 261–64 (1975) (discussing an importer's right to return flows and to recapture water spread in a groundwater basin with the intent to recapture, regardless of it's commingling with other groundwater); *City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 304 (2012), *as modified on denial of reh'g* (Dec. 21, 2012) ("[T]he priority of the overlying right does not extend to water made available by the efforts of another."); *see also* Cal. Water Code § 1745.11 ("Nothing in this article [regarding transfers involving water supplier contracts] prohibits the transfer of previously recharged groundwater from an overdrafted groundwater basin or the replacement of transferred surface water with groundwater previously recharged into an overdrafted groundwater basin, if the recharge was part of a groundwater banking operation carried out by direct recharge, by delivery of surface water in lieu of groundwater pumping, or by other means, for storage and extraction.").

197 *See* Cal. Water Code §§ 1005.1, 1005.2, 1005.4, 1011.5.

198 *Cent. & W. Basin Water Replenishment Dist. v. S. California Water Co.*, 109 Cal. App. 4th 891, 910 (2003), *as modified on denial of reh'g* (July 9, 2003).

199 *See* Adam Keats & Chelsea Tu, *Not All Water Stored Underground Is Groundwater: Aquifer Privatization and California's 2014 Groundwater Sustainable Management Act*, 9 Golden Gate U. Envtl. L.J. 93, 98–99 (2015) ("This potential conflict will become acute in the likely scenario where artificial recharge inhibits natural recharge so that it is difficult, if not impossible, to determine the relative quantity of each. Given explicit provisions in the Act and statewide policy favoring storing surface water underground, it is not difficult to envision a privately-controlled GSA systematically drawing down percolated groundwater to create storage space in the basin, and then replenishing the basin with imported water, with little consideration of the ability for overlying users to access the basin or the long-term health of the surrounding ecosystem.").

200 *See* Christian-Smith, *supra* note 195, at 2.

201 **In 2003, the California Court of Appeal rejected a proposed amendment to the Central Basin adjudication that would have allocated storage space in proportion to each pumper's groundwater extraction allocation and allowed storage rights to be transferred freely.** *See Cent. & W. Basin Water Replenishment Dist. v. S. California Water Co.*, 109 Cal. App. 4th 891, 912–13 (2003), *as modified on denial of reh'g* (July 9, 2003). **It concluded that the proposal "fail[ed] to ensure that the storage space will be used for the public benefit" because there was no guarantee that the entities that would end up owning the rights would be publicly accountable.** *Id.* at 912–13.

202 *See S. Cal. Water Co. v. City of La Verne et al.*, Case No. KC029152, at 17 (Cal. Super. Ct. Dec. 18, 1998) (Six Basins Area stipulated judgment).

203 *Id.*

204 *Id.* at 17–18 (distributing the burden of lost stored and carryover water in reverse order of the priorities mentioned above).

205 *Antelope Valley Groundwater Cases*, Case No. 1-05-CV-049053, at 39–41 (Cal. Super. Ct. Dec. 23, 2015) (Judgment and Physical Solution for Coordinated Proceeding No. 4408).

206 *See* Cal. Const. art X, § 2; *Light v. State Water Resources Control Bd.*, 226 Cal. App. 4th 1463, 1479 (2014), *as modified on denial of reh'g* (July 11, 2014), *review denied* (Oct. 1, 2014) (quoting *Peabody v. City of Vallejo*, 2 Cal.2d 351, 367–368 (1935)).

207 *See Joslin v. Marin Mun. Water Dist.*, 67 Cal. 2d 132, 144, 145 (1967) (denying a takings claim on the basis that "since there was and is no property right in an unreasonable use, there has been no taking or damaging of property by the deprivation of such use and, accordingly, the deprivation is not compensable"); *Peabody v. City of Vallejo*, 2 Cal. 2d 351, 383 (1935) (concluding that "the rule of reasonable use . . . applies to all water rights enjoyed or asserted in this state, whether the same be grounded on the riparian right or the right, analogous to the riparian right, of the overlying land owner, or the percolating water right, or the appropriative right").

208 *See Katz v. Walkinshaw*, 141 Cal. 116, 136–37 (1903).

209 Cal. Const. art. X, § 2.

210 *See Joslin v. Marin Mun. Water Dist.*, 67 Cal. 2d 132, 139–140 (1967) ("What is a reasonable use or method of use of water is a question of fact to be determined according to the circumstances in each particular case" and "cannot be resolved In vacuo isolated from state-wide considerations of transcendent importance. Paramount among these we see the ever increasing need for the conservation of water in this state, an inescapable reality of life quite apart from its express recognition in the 1928 amendment."); *Light v. State Water Resources Control Bd.*, 226 Cal. App. 4th 1463, 1488 (2014), *as modified on denial of reh'g* (July 11, 2014), *review denied* (Oct. 1, 2014).

211 *See* Cal. Water Code § 10720.1 (stating that, by enacting SGMA, the legislature intended "[t]o enhance local management of groundwater consistent with rights to use or store groundwater and Section 2 of Article X of the California Constitution"); *id.* § 10720.5 ("Groundwater management pursuant to this part shall be consistent with Section 2 of Article X of the California Constitution. Nothing in this part modifies rights or priorities to use or store groundwater consistent with Section 2 of Article X of the California Constitution . . . ."). **In late 2015, the SWRCB's Executive Director stated that, "[r]egardless of a water user's basis of right, using groundwater in a manner that exacerbates overdraft of the basin is . . . unreasonable."** Letter from Thomas Howard, Executive Director, State Water Resources Control Board, to Wade Horton, Director of Public Works, San Luis Obispo County, Dec. 15, 2015, *available at* http://www.waterboards.ca.gov/water_issues/programs/gmp/docs/intervention/slo_121515.pdf.

212 Cal. Const. art X, § 2.

213 **Case law includes:** *Meridian, Ltd., v. San Francisco*, 13 Cal. 2d 424, 448–50, 465, *opinion amended on denial of reh'g*, 13 Cal. 2d 424 (1939). **Statutes include:** Cal. Water Code § 1242; Cal. Water Code § 12581 ("In studying water development projects, full consideration shall be given to all beneficial uses of the State's water resources, including irrigation, generation of electric energy, municipal and industrial consumption of water and power, repulsion of salt water, preservation and development of fish and wildlife resources, and recreational facilities, but not excluding other beneficial uses of water, in order that recommendations may be made as to the feasibility of such projects and for the method of financing feasible projects."); *see also, e.g.,* Cal. Water Code §§ 1004, 1005.1, 1005.2, 1005.4, 1010, 1011.5, 1017, 1202, 1242.5–1244, 1257, 1425, 1435, 1727, 1745.07. **Regulations include:** Cal. Code Regs. tit. 23, § 659 ("Beneficial use of water includes those uses defined in this subarticle. The [SWRCB] will determine whether other uses of water are beneficial when considering individual applications to appropriate water."); *see also* Cal. Code Regs. tit. 23, §§ 660–674.

214 *See* Cal. Water Code § 1460.

215 *See id.* § 1242 ("The storing of water underground, including the diversion of streams and the flowing of water on lands necessary to the accomplishment of such storage, constitutes a beneficial use of water if the water so stored is thereafter applied to the beneficial purposes for which the appropriation for storage was made."); *Lindblom v. Round Valley Water Co.*, 178 Cal. 450, 456 (1918) ("Storage of water in a reservoir is not in itself a beneficial use. It is a mere means to the end of applying the water to such use. . . . The defendant's prescriptive rights do not extend to the impounding of the water for the mere purpose of holding it in storage."); *Millview Cnty. Water Dist. v. State Water Resources Control Bd.*, 229 Cal. App. 4th 879, 903-04 (2014), *as modified on denial of reh'g* (Oct. 14, 2014), *review denied* (Dec. 17, 2014) ("The exercise of these storage rights, however, does not constitute an appropriative use of water, which is required to create a conflicting claim that would preclude Millview's resumption of use. On the contrary, storage of water is not considered to be a beneficial use and cannot lead to the acquisition of a right of appropriative use."); *see also Applications for Groundwater Recharge / Storage*, State Water Resources Control Bd., http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/groundwater_recharge/ (last updated Oct. 5, 2016) ("A diversion to underground storage can be a method of diverting water, taking advantage of the natural storage capacity of aquifers, but to obtain a water right there must be designated beneficial use of the water placed to underground storage.").

216 *See* Cal. Water Code § 1011.5(a).

217 *Id.* §§ 1005.2, 1005.4; *see also id.* § 1005.1.

218 *See* Caitrin Chappelle et al., Just the Facts: Reforming California's Groundwater Management (June 2015), *available at* http://www.ppic.org/main/publication_show.asp?i=1106.

219 Cal. Water Code § 10726.4(a)(2).

220 **The following SGMA provisions address water rights:**

- Cal. Water Code § 10720.1 — **This section, in relevant part, explains that, "[i]n enacting this part, it is the intent of the Legislature to . . . *enhance local management of groundwater* <u>*consistent with rights to use or store groundwater*</u> *and Section 2 of Article X of the California Constitution*. It is the intent of the Legislature to preserve the security of water rights in the state to the greatest extent possible consistent with the sustainable management of groundwater."** *Id.* (emphasis added).
- Cal. Water Code § 10720.3(d) — **This subsection addresses the treatment of federal reserved water rights, stating that "[i]n an adjudication of rights to the use of groundwater, and *in the management of a groundwater basin or subbasin by a groundwater sustainability agency or by the board,* <u>*federally reserved water rights to groundwater shall be respected in full*</u>. In case of conflict between federal and state law in that adjudication or management, federal law shall prevail. The voluntary or involuntary participation of a holder of rights in that adjudication or management shall not subject that holder to state law regarding other proceedings or matters not authorized by federal law."** *Id.* (emphasis added). **It emphasizes that "[t]his subdivision is declaratory of existing law."** *Id.*
- Cal. Water Code § 10720.5(a) — **This subsection states that "*[g]roundwater management pursuant to this part shall be consistent with Section 2 of Article X of the California Constitution*."** *Id.* (emphasis added). **It explains that "<u>*[n]othing in this part modifies rights or priorities to use or store groundwater*</u> *consistent with Section 2 of Article X of the California Constitution*, except that in basins designated medium- or high-priority basins by the department, no extraction of groundwater between January 1, 2015, and the date of adoption of a groundwater sustainability plan pursuant to this part or the approval by the department of an alternative submitted under Section 10733.6, whichever is sooner, may be used as evidence of, or to establish or defend against, any claim of prescription."** *Id.* (emphasis added).
- Cal. Water Code § 10720.5(b) — **This subsection states that "<u>*[n]othing in this part, or in any groundwater management plan adopted pursuant to this part, determines or alters surface water rights or groundwater rights*</u> under common law or any provision of law that determines or grants surface water rights."** *Id.* (emphasis added).
- Cal. Water Code § 10720.5(c) — **This subsection emphasizes that "[w]ater rights may be determined in an adjudication action pursuant to Chapter 7 (commencing with Section 830) of Title 10 of Part 2 of the Code of Civil Procedure."** *Id.*
- Cal. Water Code § 10726.4(a), (a)(2) — **This subsection gives GSAs authority to "regulate groundwater extraction" by "*control[ling] groundwater extractions by* regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate, construction of new groundwater wells, enlargement of existing groundwater wells, or reactivation of abandoned groundwater wells, or *otherwise establishing groundwater extraction allocations*. Those actions shall be consistent with the applicable elements of the city or county general plan, unless there is insufficient sustainable yield in the basin to serve a land use designated in the city or county general plan."** *Id.* (emphasis added). **The subsection emphasizes that "<u>*[a] limitation on extractions by a groundwater sustainability agency shall not be construed to be a final determination of rights*</u> *to extract groundwater from the basin or any portion of the basin*."** *Id.* (emphasis added).
- Cal. Water Code § 10726.8(b) — **This subsection explains, in relevant part, that "<u>*[n]othing in this part shall be construed as authorizing a local agency to make a binding determination of the water rights*</u> *of any person or entity*."** *Id.* (emphasis added).
- Cal. Water Code § 10735.8(d), (e), (i) — **These subsections address the SWRCB's authority related to developing interim plans for probationary basins. Subsection (d) explains that, "[e]*xcept as provided in subdivision (e),* <u>*the interim plan shall be consistent with water right*</u>** <u>priorities</u>**, *subject to Section 2 of Article X of the California Constitution*."** *Id.* (emphasis added). **Subsection (e) states, in relevant part, that "[t]he board shall include in its interim plan a groundwater sustainability plan, or any element of a plan, that the board finds complies with the sustainability goal for that portion of the basin or would help meet the sustainability goal for the basin," and "[w]here, in the judgment of the board, an adjudication action can be relied on as part of the interim plan, either throughout the basin or in an area within the basin, *the board may rely on, or incorporate elements of, that adjudication into the interim plan* adopted by the board."** *Id.* (emphasis added). **The most straightforward interpretation of this language in context is that the only aspects of an interim plan that may be inconsistent with water right priorities are elements of an adjudication action.** *See id.* **Finally, subsection (i) emphasizes that "*[t]he board's authority to adopt an interim plan under this section* <u>*does not alter the law establishing water rights priorities*</u> or any other authority of the board."** *Id.*
- Cal. Water Code § 10736.4 — **This section states that "[t]he extraction or use of water extracted in violation of an interim plan under this part shall not be relied upon as a basis for establishing the extraction or use of water to support a claim in an action or proceeding for determination of water rights."** *Id.* (emphasis added).

221 *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1250 (Cal. 2000) (quoting the Court of Appeal's opinion).

222 *Id.* (quoting and approving the Court of Appeal's statements that "stipulating parties could agree to be bound by the physical solution regardless of any water rights they may have had" and that courts should "respect the rights of the stipulating parties to agree to a [solution that] waives or alters their water rights in a manner which they believe to be in their best interest" (alteration in original)).

223 *See id.* at 1249, 1250 ("Case law simply does not support applying an equitable apportionment to water use claims unless all claimants have correlative rights; for example when parties establish mutual prescription. Otherwise, cases like *City of San Fernando* require that courts making water allocations adequately consider and reflect the priority of water rights in the basin."); *see also* Eric L. Garner & Jill N. Willis, *Right Back Where We Started from: The Last Twenty-Five Years of Groundwater Law in California*, 36 McGeorge L. Rev. 413, 416 (2005).

224 **A recent law review article argued that "[a] GSA's imposition of production allocations and assessments on groundwater users should be consistent with underlying water right priorities in order to avoid a successful legal challenge."** Russell M. McGlothlin & Jena Shoaf Acos, *The Golden Rule of Water Management*, 9 Golden Gate U. Envtl. L.J. 109, 125 (2016); *see also* Rebecca Louise Nelson & Debra Perrone, *Local Groundwater Withdrawal Permitting Laws in the South-Western U.S.: California in Comparative Context*, 54 Groundwater 747, 749 (2016) ("The SGMA permitting power arises in the context of California's complex common law doctrines, which create property rights in the right to use groundwater. . . . A GSA's permitting regime would presumably *overlie and restrict* the exercise of these rights, but may not quantify or change them." (emphasis added)).

225 *Tehachapi-Cummings Cty. Water Dist., v. Armstrong*, 49 Cal. App. 3d 992, 1001 (1975).

226 *See* McGlothlin & Shoaf Acos, *supra* note 224, at 125 (describing the possibility of "creat[ing] different classes of allocations that impose different responsibilities for rampdown of production and liability for pump assessments, together with different opportunities that correlate with overlying, appropriative, and prescriptive rights").

227 *Cf.* Young & McAteer, *supra* note 83, at 25 (suggesting that domestic well users generally "be allowed to extract up to two acre-feet of water per annum," reduced to "0.5 acre-feet per household" "during periods of extreme stress").

228 *See* Young & McAteer, *supra* note 83, at 4. **Young & McAteer advocate "plac[ing] a sharing system over existing groundwater rights" "as a regulatory overlay."** *Id.* at 4, 9. **They argue that doing so "does not seek to extinguish existing groundwater rights" because "[t]o continue to extract groundwater from a well once a plan such as this has been approved and comes into full effect, it would be necessary to have an existing right," as well as to comply with the provisions of the sharing system."** *Id.* at 4.

229 *See id.* at 26 (suggesting "that either one or 10 shares be issued per acre-inch of current use" on the basis that "unit shares, rather than shares defined as a proportion, makes it much cheaper to realign zone boundaries" because "only those shares involves in the adjustment process need to be canceled in one zone and reissued in the other").

230 *Compare City of Pasadena v. City of Alhambra et al.*, Case No. C-1323, at 10–13 (Cal. Super. Ct. Dec. 23, 1944) (Raymond Basin judgment) and *City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 928–33 (1949) (establishing the doctrine of mutual prescription), *with* Langridge et al., *supra* note 160, at 14, 17 (stating that after "the [1979] ULARA adjudication, courts have awarded rights depending on particular circumstances in a basin and have generally adhered to classic water law," for example, in the 2004 Beaumont Basin adjudication, "the appropriators agreed to give the estimated safe yield to the overlyers" and, "[i]n exchange, the appropriators were provided with access to a temporary surplus over a nine-year period") *and San Timoteo Watershed Mgmt. Authority v. City of Banning et al.*, Case No. RIC 389197, at 2, 4, 6, 7–8, Exhibit C (Ca. Super. Ct. Feb. 4, 2004).

231 *Cf.* Matthew Fienup, Water Markets 101, Water Market Solutions for California Water Issues Workshop: Session 1: Resource Economics and How Water Markets Operate, Apr. 29, 2016, Sacramento, Cal. (workshop panelist) (discussing the threat of adjudication and the benefit of getting stakeholders to agree on allocation); *see also* Escriva-Bou et al. Report, *supra* note 101, at 20–21 (discussing the importance of quantification and the availability of a streamlined adjudication process).

232 *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1252, 1256 (2000) (quoting the Court of Appeal's decision in the case and affirming this aspect of the Court of Appeal's judgment; emphasizing that agreed-to changes were acceptable "so long as the rights of the nonstipulating parties were respected"); *see also* Cal. Civ. Proc. Code § 850 (requiring future comprehensive adjudication judgments to be "consistent with the water right priorities of all non-stipulating parties and any persons who have claims that are exempted pursuant to Section 833 in the basin" and to "treat[] all objecting parties and any persons who have claims that are exempted pursuant to Section 833 equitably as compared to the stipulating parties").

233 Langridge et al., *supra* note 160, at 19 (stating also that, "[i]n the Santa Maria Basin, overlyers in the Santa Maria Valley and the Nipomo Mesa Management Areas were granted priority water rights whether or not those rights were exercised, and only have to reduce their collective pumping if a severe water shortage occurs").

234 **The Upper Los Angeles River Area adjudication places no restrictions on when carryover accumulated by the cities of Los Angeles, Glendale, Burbank, or San Fernando in the San Fernando Basin through in lieu storage must be used.** *See City of Los Angeles v. City of San Fernando et al.*, Case No. 650079, at 16–17 (Cal. Super. Ct. Jan. 26, 1979); *see also* Watermaster in the Upper Los Angeles River Area, Annual Report: 2012–13 Water Year, at 2-32 (2014), *available at* http://ularawatermaster.com/public_resources/WY-2012-13-ULARA-WM-Rpt-12-2014.pdf (stating that "the Judgment does not limit either the amount of Stored Water Credits that a Party can accumulate or the time period over which those Stored Water Credits are allowed to accumulate").

235 **For example, the Six Basins, Mojave Basin Area, and Puente Basin adjudications limit carryover to 1 year.** *See S. Cal. Water Co. v. City of La Verne et al.*, Case No. KC029152, at 15 (Cal. Super. Ct. Dec. 18, 1998) (Six Basins Area judgment) (noting that carryover rights "may be lost" under certain conditions); *City of Barstow, et al v. City of Adelanto*, et al, Case No. 208568, at 8–9 (Cal. Super. Ct. Jan. 10, 1996), *available at* http://www.mojavewater.org/files/Judgment.pdf; *Puente Basin Water Agency et al. v. The City of Industry et al.*, Case No. C 369 220, at 12–13 (Cal. Super. Ct. July 10, 1986). **The Upper Los Angeles River Area adjudication limits carryover in the Sylmar Basin to 5 years.** *See City of Los Angeles v. City of San Fernando et al.*, Case No. 650079, at 19–20 (Cal. Super. Ct. Jan. 26, 1979).

236 **The Six Basins adjudication limits carryover to a maximum of 25% of the party's allocation for the prior year.** *See S. Cal. Water Co. v. City of La Verne et al.*, Case No. KC029152, at 15 (Cal. Super. Ct. Dec. 18, 1998) (Six Basins Area judgment).

237 *See Tehachapi-Cummings Cnty. Water Dist. v. City of Tehachapi et al.*, Case No. 97210. (Cal. Super. Ct. Mar. 23, 1971); Tehachapi-Cummings Cnty. Water Dist., Thirty-Eighth Annual Watermaster Report for Tehachapi Basin (2011), *available at* http://tccwd.com/wp-content/uploads/Tehachapi%20Basin%20Watermaster%20Report%20-%202011-Compressed.pdf.

238 *See Chino Basin Municipal Water Dist. v. City of Chino et al.*, Case No. RCV 51010 (Cal. Super. Ct. Sept. 27, 2012) (Order adopting Restated Judgment and Restated Judgment). **The Restated Judgment defines "Safe Yield" as "[t]he long-term average annual quantity of ground water (excluding replenishment or stored water but including return flow to the Basin from use of replenishment or stored water) which can be produced from the Basin under cultural conditions of a particular year without causing an undesirable result."** *Id.* at 4. **"Operating Safe Yield" is "[t]he annual amount of ground water which Watermaster shall determine, pursuant to criteria . . . can be produced from Chino Basin by the Appropriative Pool parties free of replenishment obligation under the Physical Solution herein."** *Id.*

239 *See City of Barstow, et al v. City of Adelanto*, et al, Case No. 208568, Exhibit F (Cal. Super. Ct. Jan. 10, 1996), *available at* http://www.mojavewater.org/files/Judgment.pdf; Mojave Basin Area Watermaster, Twenty-Second Annual Report of the Mojave Basin Area Watermaster, Water Year 2014–15, at 5–8 (2016), *available at* http://www.mojavewater.org/files/22AR1415_49s1d144.pdf; *see also* Donohew, *supra* note 86, at 11–12.

240 *See Cal. Am. Water v. City of Seaside et al.*, Case No. M66343, at 13, 32 (Cal. Super. Ct. Mar. 22, 2006) (Seaside Basin decision).

241 *See, e.g.*, Charalambous, *supra* note 74, at 168 (noting that "[s]trong political ideology has been a factor—and often the driving force— behind the adoption of market principles for the management of water resources" even though , "[i]n addition to economic considerations," such a decision should "take account of aspects of resource sustainability, environmental protection, social equity, and sensitivity to cultural and political perceptions"); *see also OtPR's Questions for New or Additional Water Markets*, On the Public Record (Dec. 1, 2015), https://onthepublicrecord.org/2015/12/01/otprs-questions-for-new-or-additional-water-markets/.

242 **Groundwater sustainability plans must describe how sustainability goals will be met.** *See* Cal. Water Code § 10727.2(b)(2); Cal. Code Regs. tit. 23, § 354.44 (requiring plans to describe "the projects and management actions the Agency has determined will achieve the sustainability goal for the basin," including summarizing "the permitting and regulatory process required for each," explaining "the benefits that are expected to be realized . . . and how those benefits will be evaluated," and describing "the legal authority required . . . and the basis for that authority within the Agency").

243 *See Water Markets and Tradable Permits*, Global Water Partnership, http://www.gwp.org/en/ToolBox/TOOLS/Management-Instruments/Economic-Instruments/Water-markets-and-tradable-permits/ (posted Aug. 5, 2013).

244 *See generally* Ostrom, *supra* note 83; Tomas Dietz et al., *The Struggle to Govern the Commons*, 302 Science 1907 (2003); Kaveh Madani & Ariel Dinar, *Cooperative Institutions for Sustainable Common Pool Resource Management: Application to Groundwater*, 48 Water Resources Res. W09553 (Sept. 2012).

245 *See* Tom Tietenberg & Lynne Lewis, Environmental & Natural Resource Economics 24 (10th ed. 2016) (describing externalities as exclusivity violations that occur "when an agent making a decision does not bear all of the consequences of his or her action").

246 *See, e.g.*, Tietenberg & Lewis 2012, *supra* note 87, at 23 (discussing exclusivity, transferability, and enforceability); Donohew, *supra* note 86, at 7 ("To create an environment where markets can improve water use efficiency and eliminate incentives to waste, property rights to groundwater must be well-defined, monitored and enforced, and transferable."); Scott & Coustalin, *supra* note 145, at 823, 830–31 (discussing exclusivity or specificity, transferability or assignability, flexibility, divisibility, duration or permanence, and quality of title or security); Colby Saliba, *supra* note 87, at 1116 ("Completely specified, enforceable, and transferable property rights are the ideal institutional conditions for efficient market performance."); Howe et al., *supra* note 89, at 440 (describing 6 desirable characteristics of water allocation mechanisms, which related directly to economic efficiency: flexibility, security, reflection of the real opportunity cost of the water, predictability, fairness, and reflection of public values); *see also* Joseph W. Dellapenna, *The Importance of Getting Names Right: The Myth of Markets for Water*, 25 Wm. & Mary Envtl. L. & Pol'y Rev. 317, 330 (2000) ("A "public good" is one that shares two qualities: indivisibility and publicness. Indivisibility means that a good cannot be divided up among the consuming public to allow some consumers access to the resource while excluding other potential consumers from the resource. Publicness means that the resource is shared freely (if not equally) among the group- consumption by one person does not, at least under most circumstances, interfere with consumption by others." (internal citations omitted)).

247 *See* McGlothlin & Shoaf Acos, *supra* note 224, at 120 (stating that, "in a groundwater adjudication, a physical solution can quantify and limit groundwater rights, including overlying rights, which under common law principles, are only restricted by the constitutional reasonable and beneficial use requirement. Likewise, a physical solution can allow for the application of improved groundwater management techniques *such as the transfer of overlying rights and the carryover of un-pumped rights--options not afforded by the common law*." (emphasis added, internal citation omitted); Scott S. Slater, *A Prescription for Fulfilling the Promise of A Robust Water Market*, 36 McGeorge L. Rev. 253, 267 (2005) (stating that "absent an adjudication, groundwater that might be claimed by overlying owners is generally not transferable"); Weber, *supra* note 63, at 749 n.115 (stating that "[t]he precise contours of "overlying" land and "overlying use" remain unclear").

248 **In *Burr v. Maclay Ranch Water Co.*, although the plaintiff claimed a right to use water pumped on one parcel on the other parcels he owned, he had not yet done so.** *Burr v. Maclay Rancho Water Co.*, 154 Cal. 428, 434–35 (1908). **After noting that "the plaintiff's respective blocks of land are all situated over the basin in question and each block is entitled to sufficient water from the basin for the necessary use thereon," the court theorized that "[t]he taking of it all by means of wells on one lot, instead of boring wells on each and obtaining for each the necessary water from its own well, would be a mere technical and wholly unsubstantial departure from the terms of the reservation, unless some special injury results from the location of the respective wells."** *Id.* **In that scenario, the court stated, "the most that the defendant could claim is that the plaintiff be required to take upon each block, separately acquired, the water used thereon, if the other method [pumping all water from one block owned by the plaintiff for use on all overlying blocks] proves injurious."** *Id.* **The language used in some other opinions suggests a similar take.** *See City of Pasadena v. City of Alhambra*, 33 Cal. 2d. 908, 925 (1949) (defining an overlying right as a right to use "take water from the ground underneath for use on *his land within the basin or watershed*" (emphasis added)); *see also* Anne J. Schneider, Governor's Commission to Review California Water Rights Law, Staff Paper No. 2: Groundwater Rights in California 7 (1977) ("California appellate decision have not . . . clearly defined what is

'overlying land'" but have "implie[d] that overlying use encompasses use on land within the boundaries of a groundwater basin, whether or not groundwater actually can be pumped from beneath the particular parcel of land overlying a basin."); Water rights—In general; definitions, 3 Cal. Real Est. § 9:29 (4th ed.) ("A conveyance of riparian or overlying land transfers all water rights annexed to the land without specific mention. . . . When water rights are not appurtenant to land and do not pass with a conveyance of the land (or are severed from the land by conveyance), there are several ways to effect a subsequent transfer of the rights.").

249 See *Great Oaks Water Co. v. Santa Clara Valley Water Dist.*, 242 Cal. App. 4th 1187, 1209 (2015), *review granted by* 367 P.3d 6 (Cal. 2016) ("It is undisputed . . . that the vast majority of water extracted by Great Oaks[, a company,] is not put to beneficial use upon its own land, but is sold to others for their (presumably beneficial) use. The right thus exercised—and burdened by the extraction charge—is that of an appropriator, not an overlying owner."); *see also, e.g.*, Santa Cruz, Cal., Mun. Code § 16.06.040(c) ("No person shall be permitted to sell, transport or export water from the overlying property to which the permit was issued for water well construction to assure that the use of well water shall only reasonably benefit the overlying land.").

250 *See Hildreth v. Montecito Creek Water Co.*, 139 Cal. 22, 28–29 (1903) (explaining that "the word 'appropriation,' as used in the Constitution, is not limited to water appropriated under the provisions of the Civil Code, but is general in its meaning, and includes all water, however acquired, which is devoted to public use"); *see also City of San Bernardino v. City of Riverside*, 186 Cal. 7, 10–11, 29–31 (1921) (concluding that both cities function as appropriators, where San Bernardino overlies part of the groundwater basin from which it pumps water "for the use of its inhabitants for domestic and other purposes" and Riverside lies "entirely outside of the said basin and of the watershed which supplies water thereto" and pumps and transports water "for irrigation and domestic use"; explaining that the municipality "is not substituted to nor entitled to use the water or water rights of the owners of land within its limits unless it has acquired such right directly or indirectly from such land owners, and then only for use on the particular land of such owner"); *City of Pasadena v. City of Alhambra*, 33 Cal. 2d 908, 927 (1949) ("The principal takers of water . . . are public utility corporations and municipalities which have either exported water or have used it within the Western Unit for municipal purposes or for sale to the public, and their taking, when commenced, was entirely appropriative."); *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1241 (2000) ("Any water not needed for the reasonable beneficial use of those having prior rights is excess or surplus water and may rightly be appropriated on privately owned land for non-overlying use, such as devotion to public use or exportation beyond the basin or watershed." (citing *Cal. Water Serv. Co. v. Edward Sidebotham & Son*, 224 Cal. App. 2d 715, 725 (1964))).

251 *City of San Bernardino v. City of Riverside*, 186 Cal. 7, 31 (1921).

252 *See* Pub. Util. Code § 2705 (defining a mutual water company as "[a]ny corporation or association that is organized for the purposes of delivering water to its stockholders and members at cost")

253 *See Marble & Tile Co. v. Dunsmore Canyon Water Co.*, 47 Cal. App. 72, 76–77 (1920) ("[H]ow could the ownership be terminated or the appurtenance severed by the mere substitution of the stock for the deed as evidence of ownership? The right to the flow of water was in no wise changed and the use thereof was identically the same after the issuance of the stock as it was prior thereto. The corporation was not created for profit and to pay dividends to the stockholders, but solely and alone for the convenient and more economical management of a common source of water in the distribution of and from which, according to their respective rights, the owners of these several tracts of land were entitled to a supply of water for use thereon."); *see also Corona City Water Co. v. Pub. Utilities Comm'n*, 54 Cal. 2d 834, 839 (1960) (describing "an overlying water right being exercised by a mutual [company] for the benefit of its stockholders").

254 *See City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 291 (2012), *as modified on denial of reh'g* (Dec. 21, 2012).

255 *See supra* note 181 and associated text.

256 *City of Los Angeles v. City of San Fernando*, 14 Cal. 3d. 199, 261–64 (1975) (discussing an importer's right to return flows and to recapture water spread in a groundwater basin with the intent to recapture); *City of Santa Maria v. Adam*, 211 Cal. App. 4th 266, 304 (2012), *as modified on denial of reh'g* (Dec. 21, 2012); *see also* Cal. Water Code § 1745.11.

257 McGlothlin & Shoaf Acos, *supra* note 224, at 125.

258 *See id*. **McGlothlin & Shoaf Acos point to an adjudication as an example, noting that it "creates a means to take advantage of market-based reallocations of water rights, which . . . reallocate[] water from lower to higher-valued uses, in a manner that would not be available under the common law."** *Id.* **They focus on the Amended Decision in *California Am. Water v. City of Seaside et al.*, which set up "two classes of production allocation . . . roughly similar to" appropriative and overlying rights, reflecting a compromise by the landowners in that overlying rights are not fixed in quantity."** *Id.* at 125 n.86. **Those with overlying allocations could convert their rights to appropriative allocations that could then be transferred.** *See id*. **This last step would seem to be legally questionable in an unadjudicated area.**

259 *City of Barstow v. Mojave Water Agency*, 23 Cal. 4th 1224, 1240 (2000) (quoting *Cal. Water Serv. Co. v. Edward Sidebotham & Son*, Inc., 224 Cal. App. 2d 715, 725 (1964) (internal quotation marks omitted and emphasis added).

260 McGlothlin & Shoaf Acos, *supra* note 224, at 125 n.86.

261 *See id.*; *see also Cal. Am. Water v. City of Seaside et al.*, Case No. M66343, at 19–21 (Cal. Super. Ct. Mar. 22, 2006).

262 *See supra* note 220 and accompanying text.

263 McGlothlin & Shoaf Acos, *supra* note 224, at 125.

264 *See* Young & McAteer, *supra* note 83, at 4, 10, 19.

265 *See* Fox Canyon Groundwater Mgmt. Agency, Cal., Ordinance to Establish a Combined Water Market Pilot Program and Advanced Metering Infrastructure System Demonstration Project, art.1. (adopted Dec. 9, 2016), *available at* http://www.fcgma.org/images/Water_Market-AMI_Pilot_Project.pdf.

266 *See id.*, arts. 3.G, 4.A, E.

267 *See id.*, art. 4.B.

268 *Id.*, art. 1.D.

269 Langridge et al., *supra* note 160, at 19–20, 20 fig.3.

270 *Id.* at 19–20.

271 *Id.*

272 *See* Hanak 2003, *supra* note 63, at 42.

273 *See generally*, Skurray & Pannell, *supra* note 83; *see also* Skurray et al. 2012, *supra* note 4, at 261.

274 *See* Skurray et al. 2012, *supra* note 4, at 263.

275 *See id.* at 264.

276 *See id.*

277 *See* Randall T. Hanson, Geohydrologic Framework of Recharge and Seawater Intrusion in the Pajaro Valley (2003) 58–59, *available at* http://pubs.usgs.gov/wri/wri034096/pdf/wri034096.pdf.

278 **SGMA requires groundwater sustainability plans to address "[i]mpacts on groundwater dependent ecosystems" (GDEs).** Cal. Water Code § 10727.4(l). **These include springs, wetlands, rivers, lakes, and lagoons that are critical to the species they directly support and perform many other important services. For example, GDEs can improve water quality, prevent soil erosion, provide migration corridors, and contribute aesthetic, recreational, and economic value.** *See* Isabel C. Pérez Hoyos et al., *A Review of Advances in the Identification and Characterization of Groundwater Dependent Ecosystems Using Geospatial Technologies*, 6 Geosciences *2 (2016), doi:10.3390/geosciences6020017; Bjørn Kløve et al., *Groundwater Dependent Ecosystems. Part I: Hydroecological Status*, 14 Envtl. Sci. & Pol'y 770, 770, 779 (2011). **In many areas, GDEs exist but have not yet been identified, and in others the response to groundwater extraction may not be well understood.** *See* Pérez Hoyos et al., *supra* this note, at *3; Kløve et al., *supra* this note, at 779. **GDEs can depend in groundwater in a variety of location- and condition-specific ways. For example, some require continuous groundwater flow, while others need only periodic (e.g., seasonal) flow.** *See* Kløve et al., *supra* this note, at 770, 779.

279 *See, e.g.*, Jan Fleckenstein et al., *Managing Surface Water-Groundwater to Restore Fall Flows in the Cosumnes River*, 130 J. Water Resources Planning & Mgmt. 301 (2004) (explaining that, although the Cosumnes River "historically supported a large fall run of Chinook salmon," in recent years "the entire lower river has frequently been completely dry throughout most of the salmon migration period," and studies "suggest that loss of base flow support as a result of groundwater overdraft is at least partly responsible"); Rebecca M. Quinones et al., *Potential Factors Affecting Survival Differ by Run-Timing and Location: Linear Mixed-Effects Models of Pacific Salmonids (*Oncorhynchus *spp.) in the Klamath River, California,* 9 PLoS ONE *2 (2014), doi:10.1371/journal.pone.0098392 (noting that Scott River flows "are sustained by snowmelt and groundwater inputs from the Scott Valley aquifer," and that "[r]emoval of water for irrigation exacerbates low base flows to the extent that long stream reaches dried in about four of the last 12 years" (internal citation omitted)).

280 *See, e.g.,* David J. Cooper et al., *Effects of groundwater pumping on the sustainability of a mountain wetland complex, Yosemite National Park, California*, 3 J. of Hydrology 87 (2015) (finding that "[t]he effect of pumping varied by distance from the pumping well, depth of the water table when the pumping started, and that water year's snow water equivalent (SWE)" and suggesting that managers "(1) reduce or eliminate pumping during July and August in water years with below average SWE, and (2) allow normal pumping in summers following winters with above average SWE"); Paul M. Barlow & Stanley A. Leake, Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow 26–29, 73–74 (2012), *available at* http://pubs.usgs.gov/circ/1376/pdf/circ1376_barlow_report_508.pdf (discussing variable and cyclic pumping effects and methods of potentially managing streamflow depletions); *see also* B.F. J. Kelly et al., *Aquifer Heterogeneity and Response Time: The Challenge for Groundwater Management*, 64 Crop & Pasture Sci. 1141, 1152–53 (2013); Kelly M. Cobourn, *Externalities and Simultaneity in Surface Water-Groundwater Systems: Challenges for Water Rights Institutions*, 97 Am. J. Agric. Econ. 786 (2015). **Simultaneous water diversions and extractions for frost protection in the Russian River stream system that rapidly lowered stream levels and stranded fish led the SWRCB to impose a regulation requiring locals to develop Water Demand Management Programs that avoid stranding mortality "by coordinating or otherwise managing diversions to reduce instantaneous demand."** Cal. Code Regs. tit. 23, § 862 (addressing both surface water diversions and "the pumping of hydraulically connected groundwater"); *Light v. State Water Resources Control Board*, 226 Cal. App. 4th 1463, 1472, 1475 (2014). **Five Water Demand Management Programs were approved for the 2016 frost protection season.** *See Frost Protection Regulation*, State Water Resources Control Bd., http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/russian_river_frost/ (last updated Feb. 19, 2016).

281 *See, e.g.,* Nicholas Brozović, et al., *Optimal Management of Groundwater Over Space and Time*, *in* Frontiers in Water Resource Economics 109, 125 (2006) ("Under certain hydrological conditions . . . , effects of pumping may be widely transmitted throughout the aquifer. However, in other aquifers, the extent of the externality imposed by one user on another users is limited."); Stanley A. Leake & Paul M. Barlow, Understanding and Managing the Effects of Groundwater Pumping on Streamflow 2, 3 (2013), *available at* http://pubs.usgs.gov/fs/2013/3001/fs2013-3001.pdf.

282 *See* Graham Fogg, Overview of California Groundwater, California Water Policy Seminar 2015: Groundwater Problems and Prospects, Jan. 5, 2015, at 8–9 *available at* https://watershed.ucdavis.edu/files/biblio/1_05_2015_transcript_gwseminar.pdf.

283 *See id.* at 8, 15–16.

284 *See* Skurray et al. 2012, *supra* note 4, at 265; Fogg, *supra* note 282, at 14–15 ("[T]he consequences unfold on a time scale of decades to centuries. It's not one of these things where you can look at it and monitor for 10 years and say, 'Oh yeah, I've got cause and effect. I need to do X to fix it.'"); Nicholas Brozović et al., *supra* note 281, at 112 ("[I]mpacts will be lagged: a change in one user's behavior may not be observed by other users for some time.").

285 Cal. Water Code § 10726.4(a)(4).

286 **The provision seems to establish a 5-year rolling extraction "account" balance. GSAs could potentially learn from the state of Kansas' "Multi-year Flex Account Program," which "allows users to exceed their annual authorized quantity in any year but restricts the total pumping over the 5-year period."** *See* Escriva-Bou et al. Appendix, *supra* note 101, at 73–74.

287 *See* Fox Canyon 2014 Annual Report, *supra* note 7, at 22, 22 tbl.6, 24 ("The accumulation of credits represents a long-term resource management challenge for the Agency and its stakeholders. However, while Emergency Ordinance E is in effect, Conservation Credits cannot be earned or used."); Ordinance E, *supra* note 136, art. 3. **Similarly, parties to the Upper Los Angeles River Adjudication have accumulated a large quantity of carryover credits "without sufficient 'real' groundwater in storage to access these credits."** Langridge et al., *supra* note 160, at 19, 29.

288 *See* Christian-Smith, *supra* note 195, at 2.

289 *See* Cal. Water Code § 10721(x).

290 *See* Escriva-Bou et al. Report, *supra* note 101, at 15.

291 *See* Heather Cooley, California Agricultural Water Use: Key Background Information 1–2 (2015), *available at* http://pacinst.org/app/uploads/2015/04/CA-Ag-Water-Use.pdf.

292 *See* Cobourn, *supra* note 280, at 786.

293 *See* Cooley, *supra* note 291, at 5.

294 *See* Heather Cooley et al., Impacts of California's Ongoing Drought: Agriculture 8 (2015), *available at* http://pacinst.org/app/uploads/2015/08/ImpactsOnCaliforniaDrought-Ag.pdf.

295 *See, e.g.,* State Water Resources Control Bd., August 2016 Statewide Conservation Data Fact Sheet, *available at* http://www.waterboards.ca.gov/water_issues/programs/conservation_portal/docs/2016oct/fs100516_august_factsheet.pdf; Kirsten James, *Water Reuse in California: Overcoming the Barriers to Its Expansion*, Water Deeply, Oct. 5, 2016, https://www.newsdeeply.com/water/community/2016/10/05/water-reuse-in-california-overcoming-the-barriers-to-its-expansion; Matt Weiser, *Tapping Storm Flows to Boost California's Urban Water Supplies*, Water Deeply, Sep. 26, 2016, https://www.newsdeeply.com/water/articles/2016/09/26/tapping-storm-flows-to-boost-californias-urban-water-supplies.

296 *See* Cal. Water Code § 10721(x)(3), (4).

297 *See* Cal. Dep't Water Resources, Water Transfer Approval: Assuring Responsible Transfers (2012), *available at* http://www.water.ca.gov/watertransfers/docs/responsible_water_transfers_2012.pdf; Water Transfers and the Delta Plan, *supra* note 59, at 7, 26 ("[W]hile a diverter is typically not required to return unused water back to the source, in many cases a significant portion of the water diverted is returned to the watercourse. This return flow contributes to the water supply and often represents a significant portion of the water supply for other legal users downstream").

298 *See* Water Transfer Approval, *supra* note 297, at 4.

299 *See generally* Water Transfer Approval, *supra* note 297 (focusing on injury to surface water rights and bringing up groundwater in the context of groundwater substitution transfers and their potential impacts to surface water users). *But see* SWRCB Order WR 2000-13, pp. 25-26; SWRCB Decision 1614 (1987), p. 2 (describing SWRCB's responsibility to consider impacts on interconnected surface water); *Hudson v. Dailey*, 156 Cal. 617, 628 (1909) (holding, where there was no evidence the plaintiff's riparian use of surface water from a stream interfered with upstream groundwater pumpers' overlying use of percolating water that fed the stream, that their rights "in this common supply of water would therefore be coequal, except as to quantity, and correlative").

300 *See supra* note 65 and accompanying text.

301 *See* Ellen Hanak et al., Managing California's Water: From Conflict to Reconciliation 275 (2011), *available at* http://www.ppic.org/content/pubs/report/R_211EHR.pdf.

302 *See* Cal. Water Code § 10721(x)(6).

303 *See generally* James Ayars, *On-Farm Irrigation and Drainage Practices, in* Agricultural Salinity Assessment and Management, at 511 (Wesley W. Wallender & Kenneth K. Tanji eds., 2d ed. 2012); U.S. Geological Survey, Where Do the Salts Go? (1999), *available at* https://pubs.usgs.gov/fs/fs-170-98/pdf/fs17098.pdf.

304 *See Contaminants Found in Groundwater*, U.S. Geological Survey, https://water.usgs.gov/edu/groundwater-contaminants.html (last modified Dec. 2, 2016).

305 *See id.*

306 *Cf.* Skurray et al. 2012, *supra* note 4, at 256, 261, 262 (describing current, and future, intertwined social and environmental impacts).

307 *See* Skurray & Pannell, *supra* note 83, at 881; State Water Resources Control Bd., Communities that Rely on a Contaminated Groundwater Source for Drinking Water: Report to the Legislature 5, 7–8 (2012), *available at* http://www.waterboards.ca.gov/gama/ab2222/docs/ab2222.pdf.

308 *Cf.* Heather Cooley et al., Drought and Equity in the San Francisco Bay Area 6–7 (2016), *available at* http://pacinst.org/app/uploads/2016/06/drought_and_equity_in_the_san_francisco_bay_area-5.pdf (addressing key issues and concerns more generally).

309 Sax, *supra* note 93, at 15.

310 *See id.*

311 *Id.* **Groundwater markets could potentially be designed and implemented in ways that benefit disadvantaged communities.** *See* Scott Sellers et al., Better Access. Healthier Environment. Prosperous Communities. Recommended Reforms for

the California Water Market 8 (2016), available at https://www.edf.org/sites/default/files/california-water-market.pdf ("A well-designed market can benefit these interests by not only preserving essential protections for these groups against unintended consequences of transfers—such as public hearings and "no injury" reviews—but by incorporating incentive mechanisms into the market that can directly improve water security for DACs and the environment beyond existing protections. Reforms should include provisions that ensure these entities benefit from increased water sharing throughout the state through trades that create multiple benefits for water users and the environment, increased access to financial resources to support drinking water projects, or otherwise.").

312 Cal. Water Code § 106.3.

313 *Id.* § 106.3(b). **For example, when the SWRCB adopted emergency curtailment regulations to protect fish in Mill, Deer, and Antelope Creeks in 2014 and 2015, it included an exception for diversions "necessary for minimum health and safety needs," "the amount of water necessary for prevention of adverse impacts to human health and safety, for which there is no reasonable alternate supply."** Cal. Code Regs. tit 23, § 878.1(b), (e) (effective Jun. 2, 2014 to Feb. 28, 2015), *available at* http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/mill_deer_antelope_creeks/2014_0523_05e.pdf; Cal. Code Regs. tit 23, § 878.1 (a), (d) (effective Mar. 30, 2015 to Dec. 29, 2015), *available at* http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/emergency_regulations/em_reg_oal_approval2015_0320_06ee.pdf.

314 Cal. Code Regs. tit. 23, § 350.4(g).

315 *See generally* S. Zektser et al., *Environmental Impacts of Groundwater Overdraft: Selected Case Studies in the Southwestern United States*, 47 Envtl. Geology 396 (2005).

316 *See* Brian J. Halstead et al., A Preliminary Investigation of the Variables Affecting the Distribution of Giant Gartersnakes (Thamnophis gigas) in the Sacramento Valley, California 1 (2015), *available at* http://www.water.ca.gov/watertransfers/docs/Tgigas_Sacramento_Valley_Occupancy_OFR_2015.pdf.

317 *Cf.* Skurray et al. 2012, *supra* note 4, at 256 ("An ideal groundwater trading scheme would ensure that marginal costs from trades do not exceed marginal benefits, incorporating future effects and impacts on third-parties. If this condition could be met, all transactions would result in constant or improved overall welfare.").

318 *See* Griffin, *supra* note 89, at 148.

319 *See, e.g., Water Trading Restrictions Quick Reference Table*, Australian Gov't Bureau of Meteorology, http://www.nationalwatermarket.gov.au/rules-restrictions/restrictions-reference.html (last updated Jun. 22, 2015); Skurray & Pannell, *supra* note 83, at 879–890.

320 This figure is based on the discussion and flow chart in Skurray & Pannell, *supra* note 83, at 888–89, 889 fig.2.

321 **For example, in the Upper Republican Natural Resource District in Nebraska, "[o]ne impediment to groundwater transfers has been high transaction costs" because "[t]here is no mechanism to help prospective buyers and sellers find trade partners."** Wheeler et al. 2016, *supra* note 75, at 510.

322 *See* Australian Competition & Consumer Comm'n, Water Market Intermediaries—Industry Developments and Practices 24 (2010), *available at https*://www.accc.gov.au/system/files/Water%20market%20intermediaries%20-%20industry%20developments%20and%20practices_0.pdf; Robert Brooks & Edwyna Harris, *Price Leadership and Information Transmission in Australian Water Allocation Markets*, 145 Agric. Water Mgmt. 83, 85 (2014) (describing Watermove, an exchange which matched the offers of buyers and sellers with buyers "considered on a descending scale with the highest price being the first eligible trade and the lowest the last," and sellers "considered on an ascending scale with the lowest priced seller being able to trade first and the highest, last"); Richael K. Young & Nicholas Brozović, *Innovations in Groundwater Management: Smart Markets for Transferable Groundwater Extraction Rights*, 17 Tech. & Innovation 219, 223 (2016).

323 *See* Australian Competition, *supra* note 322, at 4.

324 *See* Australian Competition, *supra* note 322, at 25–27. **So-called "water banks" run by government entities are essentially pooled exchanges, but they are not true markets, since a single entity acts as the sole purchaser and sole seller.** *See* Tietenberg & Lewis 2012, *supra* note 87, at 33 ("Environmental problems also occur when one of the participants in an exchange of property rights is able to exercise an inordinate amount of power over the outcome. This can occur, for example, when a product is sold by a single seller, or *monopoly*." (emphasis in original)); Dellapenna, *supra* note 246, at 362 (discussing the California Water bank, where the state was the only buyer and the only seller; stating that the state did "not concern itself with the effects of its transactions on third parties, even if the affected third parties h[e]ld valid water rights"). **In Dellapenna's view, "the California Water Bank transferred wealth from relatively small, poorer farmers to relatively wealthier middle class urban dwellers."** *Id.* at 364.

325 *See* Australian Competition, *supra* note 322, at 24.

326 *See id*.

327 *See* Tietenberg & Lewis 2016, *supra* note 245, at 32–34 (discussing problems associated with information asymmetry and differences in the power of trading parties).

328 *See* Young & Brozović, *supra* note 322, at 222–24 (advocating so-called "smart markets" that "leverage the power of computer-aided optimization to maximize the economic gains for otherwise decentralized trading activity," "can be customized to incorporate and automate the process of checking trading rules that complicate manual matching of buyers and sellers," and "automate the process of regulatory compliance" while keeping "bidding activity . . . anonymous and confidential" and "us[ing] a price discovery mechanism that treats buyers and sellers equitably, splitting the gains evenly between them").

329 **The Australian experience reveals mixed results. Australia's water markets are often facilitated by intermediaries such as water brokers, water exchanges, or lawyers.** Australian Gov't Nat'l Water Comm'n, Australian Water markets Report 2012-13, at 23–27 (2013) *available at* http://webarchive.nla.gov.au/gov/20160615064023/http://www.nwc.gov.au/publications/topic/water-industry/

australian-water-markets-report-2012-13. **While the country's electronic trading platforms incorporate tens of thousands of trading rules,** *see id.*, **there are several different platforms that don't communicate with one another, including several run by brokerage firms and several exchanges; in practice, a few large brokerage firms dominate these markets, and there is a lack of transparency regarding price and other aspects of trades.** *See* James Horne, *Water Information as a Tool to Enhance Sustainable Water Management—The Australian Experience*, 7 Water 2161, 2170 (2015) (describing "the absence of accurate (full price disclosure) and timely (better than weekly) price data, organized in a manner useful to market participants (through a single portal)" and "an ongoing substantial weakness in Australian water information on water trading" and noting that "[a]ll the necessary data are capable of being collected within existing state-based administrative frameworks when individual transactions are registered"); Lee West, Lessons Learned from Real World Electronic Water Exchanges, Water Market Solutions for California Water Issues Workshop: Session 2: Water Market Trading Platforms—Practical Examples, Apr. 29, 2016, Sacramento, Cal. (workshop panelist) (stating that a handful of large brokerage firms dominate the Australian water markets, and arguing that there is a detrimental lack of transparency surrounding brokered trades, including timely price data).

330 *See, e.g.,* Graham Fogg, *The Hidden Treasure of California's Groundwater*, Water Deeply, July 15, 2016, https://www.newsdeeply.com/water/op-eds/2016/07/15/the-hidden-treasure-of-californias-groundwater (discussing how lack of information about groundwater impairs both surface water and groundwater management).

331 *See* Claudia C. Faunt et al., *Water Availability and Land Subsidence in the Central Valley, California, USA*, 24 Hydrogeology J. 675, 675 (2016) ("As land use, managed aquifer recharge, and surface-water availability continue to vary, long-term groundwater-level and subsidence monitoring and modelling are critical to understanding the dynamics of historical and continued groundwater use resulting in additional water-level and groundwater storage declines, and associated subsidence."); Janny Choy et al., *Groundwater Data: California's Missing Metrics*, Water in the West (published July 31, 2014, updated Dec. 19, 2014), http://waterinthewest.stanford.edu/groundwater/metrics/ ("Groundwater models are used to understand how groundwater flows through aquifers in a groundwater basin and how they are affected by recharge (surface water, precipitation, etc.) and discharges (. . . pumping, springs and seeps, rivers, etc.)." They "integrate a variety of data (and estimates) regarding subsurface geology, land uses, hydrology, climate, water supply and demand.").

332 **A study published in 2014 by researchers at Stanford's Water in the West program concluded that managers in many groundwater basins across the state did not collect crucial groundwater data (drilling logs, production metering data for private wells, and groundwater elevation data) and most had not developed groundwater models.** *See* Choy et al., *supra* note 331.

333 *See California Statewide Groundwater Elevation Monitoring (CASGEM) Program*, Cal. Dep't Water Resources, http://www.water.ca.gov/groundwater/casgem/ (last modified Aug. 25, 2016); *see also* 2009–10 7th Extraordinary Session Cal. Legis. Serv. ch. 1 ["S.B.x7-6"] (codified at Cal. Water Code §§ 10920–10936); Cal. Dep't Water Resources, Status Report on Implementation of the California Statewide Groundwater Elevation Monitoring Program Years 2012–2015, at 2 (2016), *available at* http://www.water.ca.gov/groundwater/casgem/pdfs/CASGEM_5_year_Report.pdf.

334 *See* Status Report, *supra* note 333, at 6–7 (2016), *available at* http://www.water.ca.gov/groundwater/casgem/pdfs/CASGEM_5_year_Report.pdf (identifying "insufficient density of monitoring locations"; "well construction information gaps, such as CASGEM wells with missing total depth and/or screened intervals"; "temporal data gaps, including CASGEM wells not being monitored . . . at least twice per year (spring and fall) to capture seasonal and long-term trends"; and "insufficient monitoring plans by Monitoring Entities, including . . . failures to identify and mitigate monitoring gaps"). **As of the end of 2015, 239 of the 515 Bulletin 118 basins were monitored by 5,706 wells under the CASGEM Program, including 3 partially monitored medium-priority basins and 2 partially monitored high-priority basins.** *Id.* at 2, 4. **Three medium priority basins were considered fully unmonitored.** *See id.* at 4.

335 *See generally, e.g.*, *Meredith Goebel et al., Resistivity Imaging Reveals Complex Pattern of Saltwater Intrusion Along Monterey Coast*, J. Hydrology (2017) (corrected proof), http://dx.doi.org/10.1016/j.jhydrol.2017.02.037; Rosemary G. Smith et al., *Estimating the Permanent Loss of Groundwater Storage in the southern San Joaquin Valley, California*, Water Resources Res. (2017) (accepted Author manuscript), doi:10.1002/2016WR019861; Faunt et al., *supra* note 331; Alissa L. Coes et al., Initial Characterization of the Groundwater System near the Lower Colorado Water Supply Project, Imperial Valley, California (2015), *available at* https://pubs.er.usgs.gov/publication/sir20155102; Cooper et al., *supra* note 280, at 87; Claudia C. Faunt et al., Hydrogeology, Hydrologic Effects of Development, and Simulation of Groundwater Flow in the Borrego Valley, San Diego County, California (2015), *available at* https://pubs.er.usgs.gov/publication/sir20155150; R. T. Hanson, *Hydrologic Framework of the Santa Clara Valley, California*, Geosphere 11(3) (2015), http://dx.doi.org/10.1130/GES01104.1; Robert Kent, Groundwater Quality Data in 15 GAMA Study Units: Results from the 2006–10 Initial Sampling and the 2009–13 Resampling of Wells, California GAMA Priority Basin Project (2015), *available at* https://pubs.er.usgs.gov/publication/ds919; Adam Siade et al., *Natural recharge estimation and uncertainty analysis of an adjudicated groundwater basin using a regional-scale flow and subsidence model (Antelope Valley, California, USA)*, 23 Hydrogeology J. 1267 (2015); Michelle Sneed et al., Land Subsidence, Groundwater Levels, and Geology in the Coachella Valley, California, 1993–2010 (2014), *available at* https://pubs.er.usgs.gov/publication/sir20145075; Thomas Harter et al., Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater (2012), *available at* http://groundwaternitrate.ucdavis.edu/files/138956.pdf; Andrew J. Racz et al., *Spatial and Temporal Infiltration Dynamics During Managed Aquifer Recharge*, 50 Groundwater 562 (2011); Jan H. Fleckenstein et al., *River-Aquifer Interactions, Geologic Heterogeneity, and Low-Flow Management*, 44 Groundwater 837 (2006); Gary S. Weissmann et al., *Dispersion of Groundwater Age in an Alluvial Aquifer System*, 38 Water Resources Res. 16-1 (2002); K.J. Larson et al., *Prediction of Optimal Safe Ground Water Yield and Land Subsidence in the Los Banos-Kettleman City Area, California, Using a Calibrated Numerical Simulation Model*, 242 J. of Hydrology 79 (2001); Sally M. Benson et al., *Groundwater Contamination at the Kesterson Reservoir, California: 1. Hydrogeologic Setting and Conservative Solute Transport*, 27 Water Resources Res. 1071 (1991).

336 *See, e.g.*, Tara Moran et al., From the Ground Down: Understanding Local Groundwater Data Collection and Sharing Practices in California 15, 20, 23–24 (2016), *available at* http://waterinthewest.stanford.edu/sites/default/files/GW-DataSurveyReport.pdf (finding that "[s]urvey respondents overwhelmingly identified two areas for improvement: the need for additional data (46 responses, 90 percent) and the need for standardization of methods and a common data-sharing platform (23 responses, 58 percent)" with groundwater extraction data, groundwater level data, private well information, water quality data, real-time data, and data related to groundwater/surface water interactions identified highlighted as important data gaps); Water in the West, Workshop Summary: Groundwater Models in the SGMA Context, held Nov. 16, 2015, at 2, 4, 6 *available at* http://waterinthewest.stanford.edu/sites/default/files/related_documents/GWModelWorkshop_Summary_Final12.16.2015.pdf (stating that "in California, we are often missing key data (e.g., groundwater pumping rates, aquifer hydraulic data)" which "can ultimately lead to a high degree of uncertainty in model outputs, regardless of how good the model is" and noting that there is "limited knowledge of surface-groundwater interactions"); Cal. Dep't Water Resources, California's Groundwater Update 2013: A Compilation of Enhanced Content for California Water Plan Update 2013: Findings, Data Gaps, and Recommendations 3–4 (2015), *available at* http://www.water.ca.gov/waterplan/topics/groundwater/index.cfm (identifying gaps in data collection and analysis and basin assessment); Cal. Dep't Water Resources, Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California (2014), *available at* http://www.water.ca.gov/groundwater/docs/Summary_of_Recent_Historical_Potential_Subsidence_in_CA_Final_with_Appendix.pdf (finding that "[m]any high and medium priority basins do not have subsidence monitoring networks or long-term groundwater monitoring wells, most notably in the Central Coast Hydrologic Region" and that "[l]arge areas of recent subsidence in the San Joaquin Valley (El Nido and Tulare-Kettleman areas) do not have continuous GPS or borehole extensometers in the areas of maximum subsidence" (internal citations omitted)); Borchers et al., *supra* note 1, at 104; Bulletin 118, Update 2003, *supra* note 36, at 2, 106, 109 fig.21 (finding that "[f]ew basins have detailed water budgets by which to estimate overdraft"; that, "[w]hile the most extensively developed basins tend to have information, many basins have insufficient data for effective management or the data have not been evaluated"; that "lack of essential data," not technological limitations, limit the ability "to determine basin conditions"; and that adequate electronic land use data are not available "for making groundwater extraction estimates").

337 Cal. Code Regs. tit. 23, § 354.34(a).

338 *See* Escriva-Bou et al. Report, *supra* note 101, at 22.

339 Cal. Code Regs. tit. 23, § 354.34(c).

340 *See* James H. Skurray, Compliance, Cooperation, and Credibility: Institutions and Enforcement in California Groundwater 2 (2015) (Working Paper 1404, School of Agricultural & Resource Economics); *see also* Skurray 2015, *supra* note 100, at 138.

341 *See* Skurray 2015, *supra* note 100, at 136; Ostrom, *supra* note 83, at 203–04.

342 *See e.g.*, Aladjem & Sunding, *supra* note 83, at 3 ("Establishing groundwater markets also requires enforcement of use limits when violations occur.").

343 Cal. Water Code § 10728.2.

344 Cal. Water Code § 10728.2.

345 *See* Cal. Water Code §§ 10733, 10735.2(a)(3), (5).

346 **DWR identifies which basins are subject to SGMA and develops regulations for basin boundary revisions and for evaluating groundwater sustainability plans, their implementation, and coordination agreements between local agencies for groundwater sustainability planning.** *See* Cal. Water Code §§ 10722.2(b), 10722.4, 10733.2.

347 *See* Cal. Water Code § 10729(d).

348 **By the beginning of 2017, DWR must provide information to help GSAs carry out their duties, including its "best estimate, based on available information, of water available for groundwater replenishment of groundwater in the state."** Cal. Water Code § 10729(c). **DWR can also provide technical assistance to GSAs and groundwater users.** *See* Cal. Water Code § 10729(a), (b).

349 *See* Cal. Water Code § 10733.

350 *See* Cal. Water Code § 10735.2.

351 *See id.* § 10735.2(a)(3).

352 *See* Cal. Water Code § 10735.2(a).

353 *See* Cal. Water Code §§ 10735.4–10735.8. **Beginning 90 days after a basin is placed on probation, all groundwater extractions must be reported to the SWRCB, with limited exceptions.** *See* Cal. Water Code § 5202.

354 Letter *supra* note 211, at 2. **Although SGMA authorizes the SWRCB to include physical solutions in an interim plan, "local agencies and their community members will be in a better position . . . to decide whether to proceed with any particular [water supply] project and to structure a financing plan."** *Id.* (citing Cal. Water Code § 10735.8(c)); *see also* Cal. Water Code § 10735.8(c) (providing that interims plans may include "[r]estrictions on groundwater extraction," "a physical solution," and "[p]rinciples and guidelines for the administration of rights to surface waters that are connected to the basin").

355 **"Uncertainty and delay in the environmental and social impacts of groundwater use require management regimes that are flexible and adaptable, rather than rigid policies based on inadequate hydrological information, or that fail to incorporate the relevant hydrology."** Skurray et al. 2012, *supra* note 4, at 262. **Therefore, "groundwater trading schemes should be designed and managed with sensitivity to hydrological conditions, as well as to our evolving understanding and knowledge of those conditions."** *Id.*

356 Christian-Smith & Abhold, *supra* note 114, at 7.

357 *Id.*; *see also* Kai N. Lee, *Appraising Adaptive Management*, Ecology & Soc'y 3(2), art. 3, http://www.ecologyandsociety.org/vol3/iss2/art3/.

358 *See* Murray-Darling Basin Authority, Basin Plan Annual Report 2014–15: Towards a Healthy, Working Murray-Darling Basin 43 (2015), *available at* http://www.mdba.gov.au/sites/default/files/pubs/The-Basin-Plan-annual-report-2014-15_1.pdf.

359 *See* Kiparsky et al., *supra* note 44, at 35–37 (discussing direct stakeholder engagement in GSAs' decision making processes).

360 *See* Cal. Water Code § 10727.8(a) ("Prior to initiating the development of a groundwater sustainability plan, the groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan.").

361 *Id.* § 10727.8(a).

362 *Id.* § 10723.2.

363 *Id.*

364 *Id.* § 10723.4.

365 *Id.* § 10728.4.

366 *Id.* § 10727.8(a); *see also* Kearns & West, *supra* note 133, at 5, 6 (stating, "[r]egardless of GSA structure, ensure consistent and appropriate public accessibility and transparency around GSA formation dialog and decision making" and suggesting the possibility of developing "a SGMA Implementation Forum or similar structured public discussion").

367 *See* Bulletin 118, Update 2003, *supra* note 36, at 55 ("The managing entity should establish an advisory committee of interested parties that will help guide the development and implementation of the plan.").

368 **Participation is meaningful when power is actually shared with stakeholders in a way that allows them to influence decisions.** *See, e.g.*, Sherry R. Arnstein, *A Ladder of Citizen Participation*, 35 J. Am. Inst . Planners 216 (1969).

369 **For example, the Monterey Amendments to the State Water Project were negotiated secretly between DWR and a subset of state water contractors in 1995, generating significant controversy and a legal challenge.** *See Planning & Conservation League v. Cal. Dep't of Water Resources*, 83 Cal. App. 4th 892, 898–99 (2000); Antonio Rossmann, *Third District Court of Appeal Strikes Down Monterey Amendment EIR, Restores Public Role In State Water Project*, 11 Cal. Water L. & Pol'y Rep. 29, *2, * (Nov. 2000), *available at* http://landwater.com/wp-content/uploads/2007/07/monterey-eir-strick-down.pdf.

370 *See* David Sneed, *Voters Reject Pas Robles Groundwater Basin District,* The Tribune, Mar. 8, 2016, *available at* http://www.sanluisobispo.com/news/local/article64904542.html.

371 *See* Bulletin 118, Update 2003, *supra* note 36, at 55; Kearns & West, *supra* note 133, at 17 ("Water transfers, water rights, and the appropriate uses of surface and groundwater have been ongoing sources of public disagreement and debate for at least two decades. . . . SGMA implementation offers opportunities to set aside past conflicts without abandoning core values and pursue more constructive public conversations around water resource management. The processes for GSA formation and GSP development will be enriched to the extent individuals and organizations take advantage of opportunities to move beyond past disagreements."); Charalambous, *supra* note 74, at 99, 169 ("Experience shows that reforms, especially if controversial, imposed from above often run the risk of failure, take too long to implement or become so diluted that they fail to meet their original objectives. It is important, therefore that the concepts, objectives, benefits and risks are clearly explained and that stakeholders and others are consulted for their views and allowed to express their concerns.").

372 *See, e.g.*, Choy et al., *supra* note 331 ("Collecting technically adequate groundwater data is not enough. The inherently public nature of groundwater management requires groundwater managers to disseminate information that will garner public support for effective groundwater policies and management. In contrast to data—which are often numbers given without context—information communicates the actual and potential severity of the larger consequences of groundwater conditions and management decisions in light of local circumstances and future management plans. Where possible, information should answer questions that are important for the public to understand, such as: Is the groundwater safe to drink? Is my well going to continue to supply me with the water I need? How many local wells will dry up if groundwater elevations continue to decline?").

373 *See generally* Kristin Dobbin et al., Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation (2015), *available at* http://waterfoundation.net/wp-content/uploads/2015/07/SGMA_Stakeholder_Engagement_White_Paper.pdf. **Specific actions GSAs can take include using online databases and document libraries to increase public access to information; offering options for communication and notification beyond email correspondence; providing translation at public meetings when a significant portion of the local population speaks a language other than English; holding workshops and meetings outside of standard business hours; providing extended formal comment periods on documents and proposals; including diverse stakeholder perspectives on technical committees and working groups, in addition to stakeholder advisory boards or committees; using joint fact-finding or collaborative modeling to build shared understanding of groundwater conditions and management alternatives; conducting targeted outreach to stakeholders that may have special interest in a particular phase or section of plan development or implementation; approaching stakeholders directly to solicit their input; and seeking feedback on engagement, outreach, and communication to foster improvement.** *See id.* at 21.

374 *See* Kiparsky et al., *supra* note 44, at 23, 24 tbl.3.

375 *See id.*

376 *See id.* at 26–28.

377 *See supra* note 9 and accompanying text.

378 *See supra* note 74 and accompanying text.

379 *See supra* note 75 and accompanying text.

380 *See supra* note 76 and accompanying text.

381 *See* Charalambous, *supra* note 74, at 92–93.

382 *See id.* at 93; Ruth Meinzen-Dick & Martha Sullins, Water Markets in Pakistan: Participation and Productivity 1–2, 22 (1994) (concluding that "[w]ater markets meet a need for water among those who have too little land, cannot afford tubewells, or find the investment not worthwhile, and those who have problems with the groundwater quality on their own land). **If public supplies are unavailable, unreliable, or inconveniently located, these users may source water from their neighbors with wells.** Meinzen-Dick & Sullins, *supra* this note, at 3–6.

383 Meinzen-Dick & Sullins, *supra* note 382, at 8.

384 Meinzen-Dick & Sullins, *supra* note 382, at 6 (citing Holly Sims, Political regimes, public policy and economic development: Agricultural performance and rural changes in two Punjabs (1988)).

385 *See* A. Mukherji & T. Shah, *Socio-Ecology of Groundwater Irrigation in South Asia: An Overview of Issues and Evidence*, *in* Groundwater Intensive Use , at 53, 73 tbl.13 (A. Sahuquillo ed., 2005) (88% in Bangladesh, 62% in Nepal Terai, 46% in Eastern India, and 33% in Punjab, Pakistan).

386 *See* Charalambous, *supra* note 74, at 93; Meinzen-Dick & Sullins, *supra* note 382, at 6–8, 26; Kumar Anish Singh et al., *Groundwater Marketing in Nalanda District of Bihar State: A Socio-economic Appraisal*, 20 Agric. Econ. Research Rev. 333, 334 (2007) ("Informal markets of irrigation water extracted by the private tubewells provide an important means of increasing access to groundwater resources for non tubewell owners. . . . It is the small and medium farmers who are the sellers while the buyers are farmers who are poor and own scattered bits of land."); Sarbani Mukherjee & Durba Biswas, *An Enquiry into Equity Impact of Groundwater Markets in the Context of Subsidised Energy Pricing: A Case Study*, 5 IIM Kozhikode Soc'y & Mgmt. 63, 65 (2016) (citing T. Shaw, *Water markets and irrigation development in India*, 46 Indian Journal of Agricultural Economics 335 (1991)).

387 Meinzen-Dick & Sullins, *supra* note 382, at 8, 21–22 (finding a positive correlation between the amount of land owned and well ownership). **Since the extent of informal markets is spatially limited by the efficiency of water transmission (often via canals), monopolistic market situations with little to no competition (and therefore little price control) can develop.** *Id.* at 8.

388 *See* Charalambous, *supra* note 74, at 93; Mukherjee & Biswas, *supra* note 386, at 63, 63 ("In India, groundwater over-extraction is often linked with subsidized electricity in the agricultural sector. . . . [I]n the short run, water markets improve accessibility to groundwater irrigation, particularly for marginal and small farmers. With the help of this, farmers are able to mitigate water-scarcity-related vulnerabilities. However, in the long run, electricity subsidy may have negative dynamic implications by causing over-exploitation of groundwater that reduces the volume of groundwater available for future agricultural use. In other words, . . . in the initial phases of the development of the water markets, there are intra-generational equity implications."); Tushaar Shah, *The Groundwater Economy of South Asia: An Assessment of Size, Significance and Socio-Ecological Impacts*, at 7, 22–23, 23 fig.2.12, *in* The Agricultural Groundwater Revolution: Opportunities and Threats to Development (M. Giordano & K.G. Villholth eds. 2007) (describing the "Pathology of Decline of a Groundwater Socio-Ecology" and stating that "there are few regions left . . . where further groundwater development can be had more or less as a 'free lunch'").

389 *See* Australian Gov't Nat'l Water Comm'n, Water Markets in Australia: A Short History (2011) *available at* http://www.nwc.gov.au/__data/assets/pdf_file/0004/18958/Water-markets-in-Australia-a-short-history.pdf.

390 Australian Water markets Report 2012-13, *supra* note 329, at 16. For more on unbundling water rights, *see* Michael D. Young, *Unbundling Water Rights as a Means to Improve Water Markets in Australia's Southern Connected Murray-Darling Basin*, *in* Use of Economic Instruments in Water Policy 279, 281–86 (M. Lago et al. eds., 2015); Michael Young, Unbundling Water Rights: A Blueprint for Development of Robust Water Allocation Systems in the Western United States 9–25 (2015), *available at* https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_r_15-01.pdf.

391 Australian Gov't Nat'l Water Comm'n, Australian Water Markets: Trends and Drivers 2007–08 to 2012–13, at 36 (2014), *available at* http://webarchive.nla.gov.au/gov/20160615064017/http://www.nwc.gov.au/publications/topic/water-industry/trends-and-drivers-2012-13 (noting that groundwater is the main water source in Western Australia, where there are 10 times as many groundwater entitlements as surface water entitlements, and the Northern Territory, while there are no groundwater entitlements in Tasmania).

392 *See id.* at 37.

393 *See id.* at 36, 59.

394 *See* Australian Water markets Report 2012-13, *supra* note 329, at 15, 15 fig.2.1, 31; Murray-Darling Basin Authority, Report, *supra* note 358, at 40.

395 Murray-Darling Basin Authority, *supra* note 358, at 6.

396 *See Sustainable Diversition Limits*, Murray-Darling Basin Authority, http://www.mdba.gov.au/basin-plan-roll-out/sustainable-diversion-limits (last visited Mar. 12, 2017).

397 *See id.*

398 *See id.*

399 *See id.*

400 *See Groundwater*, Murray-Darling Basin Authority, http://www.mdba.gov.au/basin-plan-roll-out/groundwater (last visited Mar. 12, 2017).

401 *See* Murray-Darling Basin Authority, Guidelines for Water Trading Rules: Trade of Groundwater Access Rights (2014), *available at* http://www.mdba.gov.au/sites/default/files/pubs/10_WTG-GROUNDWATER-TRADING-RULES_final.pdf.

402 *Id.* at 2.

403 *See id.* at 3.

404 *See* Australian Water markets Report 2012-13, *supra* note 329, at 4 (see notes below Tables 1.1 and 1.2).

405 *See* Australian Water markets Report 2012-13, *supra* note 329, at 4 tbl.1.1, tbl.1.2.

406 *See About Us*, Edwards Aquifer Authority, http://www.edwardsaquifer.org/about/eaa (last visited Aug. 11, 2016).

407 *See* Texas Water Dev. Bd., A Texan's Guide to Water & Water Rights Marketing 12 (2003), *available at* http://www.twdb.texas.gov/publications/reports/infosheets/doc/WaterRightsMarketingBrochure.pdf.

408 *See* 1993 Tex. Gen. Laws 2361, § 1.16.

409 *See id.* § 1.34; Edwards Aquifer Authority Rules §§ 711.324–711.330.

410 *See* Zachary P. Sugg, Market-based Groundwater Allocation: Considerations for Arizona from the Texas Edwards Aquifer Cap and Trade System 3–5 (2013), *available at* https://pdfs.semanticscholar.org/1a7e/4cbf42ea49f761d24f3ab13bb4b1c12aca98.pdf (based on "transfer records obtained by public records request"). **About 43% of transfers were from agricultural to municipal or industrial use, 40% were between agricultural users, 15% were between municipal and/or industrial users, and 2% were from municipal or industrial to agricultural use.** *Id.* at 5.

411 *See* Marielle Montginoul et al., *Controlling Groundwater Exploitation Through Economic Instruments: Current Practices, Challenges and Innovative Approaches*, *in* Integrated Groundwater Management 551, 565 (A.J. Jakeman et al. eds., 2016).

412 *See* Republican River Basin Natural Resources Dists., Sustainability Steps — Previous and Planned Actions in the Republican Basin to Preserve Water 2, May 2015, *available at* http://www.urnrd.org/sites/default/files/files/20/republicanbasinsustainability.pdf.

413 *See* Upper Republican Natural Resources Dist., Neb., Rules & Regulations Order 33 for Groundwater Control, r. 8, available at http://www.urnrd.org/sites/default/files/files/20/finalrules2015.pdf.

414 *See* Amanda Palazzo & Nicholas Brozović, *The Role of Groundwater Trading in Spatial Water Management,* 145 Agric. Water Mgmt. 50, 54 (2014).

415 *See* Upper Republican Natural Resources Dist., Neb., Rules & Regulations Order 33 for Groundwater Control, r. 11, available at http://www.urnrd.org/sites/default/files/files/20/finalrules2015.pdf.

416 *See* Amanda Margaret Palazzo, Farm-Level Impacts of Alternative Spatial Water Management Policies for the Protection of Instream Flows 16, 40 tbl.1, 41 tbl.2 (2009); Palazzo & Brozović, *supra* note 414, at 53 n. 1 (explaining that the trades were identified "based on review of the NRD Board of Directors minutes during this period").

417 *See City of Barstow, et al v. City of Adelanto*, et al, Case No. 208568, at 30, 26 (Cal. Super. Ct. Jan. 10, 1996) (Judgment After Trial), *available at* http://www.mojavewater.org/files/Judgment.pdf; Langridge et al., *supra* note 160, at 192–92. **If parties pump more than their Free Production Allowance they must pay for the import of Replacement Water.**

418 *See supra* note 239 and accompanying text.

419 *See City of Barstow, et al v. City of Adelanto*, et al, Case No. 208568, at 7, 36–37 (Cal. Super. Ct. Jan. 10, 1996) (Judgement After Trial), *available at* http://www.mojavewater.org/files/Judgment.pdf.

420 *See* Mojave Basin Area Watermaster, Twenty-Second Annual Report of the Mojave Basin Area Watermaster, Water Year 2014–15, at 5, 9 (2016), *available at* http://www.mojavewater.org/files/22AR1415_49s1d144.pdf; *see also* Donohew, *supra* note 86, at 11–12; Frequently Asked Questions, Mojave Water Agency, http://www.mojavewater.org/faqs.html (last visited Oct. 12, 2016) ("There are approximately 470 water producers that are bound by the Judgment.").

421 *See supra* note 141 and accompanying text.

422 *See United States v. Fallbrook Pub. Util. Dist.*, 101 F. Supp. 298, 303 (S.D. Cal. 1951) ("By the common law the right of the riparian proprietor to the flow of the stream is inseparably annexed to the soil, and passes with it, not as an easement or appurtenance, but as part and parcel of it." (quoting *Lux v. Haggin*, 69 Cal. 255, 390 (1886)); Cal Const. art. X, § 2; Cal. Water Code § 101; *see also Water Rights Frequently Asked Questions: What is a riparian right?*, State Water Resources Control Bd., http://www.swrcb.ca.gov/waterrights/board_info/faqs.shtml#toc178761088 (last visited Oct. 17, 2016). **The practical effect of not exercising a riparian right is that more water becomes available to satisfy more junior water rights. In 1991 DWR took advantage of this feature, acquiring water for the 1991 Drought Water Bank in part by by entering into fallowing contracts with riparians that allowed the State Water Project and Central Valley Project to reduce releases from reservoirs upstream of the Delta to meet Delta water quality requirements, "making more [water] available for other water demands."** Morris Israel & Jay R. Lund, *Recent California Water Transfers: Implications for Water Management*, 35 Natural Resources J. 1, 6 (1995). **Note that riparian rights are severed from noncontiguous parts of riparian parcels sold without express conveyance of the riparian right.** *See Rancho Santa Margarita v. Vail*, 11 Cal. 2d 501, 538 (1938) ("[W]here the owner of a riparian tract conveys away a noncontiguous portion of the tract by a deed that is silent as to riparian rights, the conveyed parcel is forever deprived of its riparian status." (citing *Anaheim Union Water Co. v. Fuller*, 150 Cal. 327, 331 (1907)).

423 *People v. Shirokow*, 26 Cal. 3d 301, 307–08 (1980).

424 *Id.* at 308.

425 *See* Cal. Civ. Code § 1415; *see also* Cal Civ. Code §§ 1416–1422.

426 *See Cal. Farm Bureau Fed'n v. State Water Resources Control Bd.*, 51 Cal. 4th 421, 429 (2011), *as modified* (Apr. 20, 2011) (explaining that the SWRCB "regulates all appropriative water rights acquired since 1914 . . . through a system of permits and licenses"); *see also Water Rights Frequently Asked Questions: Do I need a water right permit if I began using water before 1914?*, State Water Resources Control Bd., http://www.swrcb.ca.gov/waterrights/board_info/faqs.shtml#toc178761091 (last visited Oct. 17, 2016) ("If you have a pre-1914 right, you do not need a water right permit unless you have increased your use of water since 1914.").

427 *See* Cal. Water Code § 1706.

428 Water Transfer Approval, *supra* note 397, at 1–2, 5; State Water Resources Control Bd., A Guide To Water Transfers (Draft) 3-7 to 3-9(1999), *available at* http://www.waterboards.ca.gov/waterrights/water_issues/programs/water_transfers/docs/watertransferguide.pdf (Note: There is no "final" version available for this document, but it is still used by the SWRCB).

429 *See* Escriva-Bou et al. Appendix, *supra* note 101, at 23; Water Transfer Approval, *supra* note 297, at 4.

430 *See* Cal. Code Regs. tit. 23, § 920(c)(10).

431 *See People v. Shirokow*, 26 Cal. 3d 301, 308 (1980); *see also* Water Commission Act of 1913, 1913 Cal. Stat. 1012.

432 *See People v. Shirokow*, 26 Cal. 3d 301, 308 (1980); *Cal. Farm Bureau Fed'n v. State Water Resources Control Bd.*, 51 Cal. 4th 421, 428–29 (2011), as *modified* (Apr. 20, 2011); *United States v. Fallbrook Pub. Util. Dist.*, 165 F. Supp. 806, 830 (S.D. Cal. 1958) (stating that, "[i]f this procedure was not the exclusive method of appropriating water after 1914, it became so in 1923 when this method of appropriation was made exclusive by amendment to the Water Commission Act (Stat.1923, c. 87)"; "[a]ppropriation by pre-emption or self help was thus terminated at least by 1923"); Cal. Water Code §§ 1228.1–1229.1 (describing registration requirements, and their applicability, for small domestic use, small irrigation use, and livestock stockpond use); *id.* §§ 1375–1415 (describing permits); *see also* Process for Water Right Licensing, *supra* note 151 (explaining that "[t]he water right process has three phases: (a) application, (b) permit, and (c) license"); *Water Rights Applications: Permitting and Licensing Program*, State Water Resources Control Bd., http://www.swrcb.ca.gov/waterrights/water_issues/programs/applications/ (last updated Jul. 12, 2016).

433 *See* Cal. Water Code §§ 1725–1727 (regarding short-term transfers); Cal. Water Code §§ 1735–1736 (regarding long-term transfers); *see also* Cal. Code Regs. tit. 23, §§ 794(b), (c) and 801 (requiring consultation with the California Department of Fish and Wildlife regarding potential effects on fish, wildlife, and water quality).

434 Cal. Water Code §§ 1725, 1728.

435 *See* Cal. Water Code § 1729.

436 Cal. Water Code §§ 1435, 1440–1442.

437 *See* Cal. Code Regs. tit. 23, § 920(c)(11).

438 *See supra* note 73 and accompanying text in **Table 1**.

439 **NEPA requires federal agencies to consider the environmental impacts of proposed actions, like approving the use of federal conveyance infrastructure. Where a groundwater transfer would involve federal parties or the approval of a federal agency (e.g., to use federal conveyance infrastructure), NEPA procedure must be followed.** *See* Water Transfers White Paper, *supra* note 77, at 7 fig. 1-1. **NEPA requires federal agencies to consider the potential environmental impacts of their proposed actions.** *See* 42 U.S.C. §§ 4321, 4331–33. **Preparation of a detailed environmental impact statement is required for federal actions that could have significant environmental impacts.** *See* 42 U.S.C. § 4332(C). **An environmental assessment may be prepared to determine whether a full environmental impacts statement is required.** *See* 40 C.F.R. §§ 1501.3, 1508.9; *see also Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172, 1185 (9th Cir. 2008). **The agency "must supply a convincing statement of reasons to explain why a project's impacts are insignificant" and make a finding of no significant impact.** *Ctr. for Biological Diversity*, 538 F.3d at 1220 (internal quotation marks omitted). **An environmental impact statement must describe "the environmental impact of the proposed action," "any adverse environmental effects which cannot be avoided should the proposal be implemented," "alternatives to the proposed action," "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity," and "any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."** 42 U.S.C. § 4332.

440 *See* 2016 Water Transfers White Paper, *supra* note 77, at 1, 7 fig. 1-1.

441 2016 Water Transfers White Paper, *supra* note 77, at 2.

442 Cal. Water Code § 1810(d); *see also id.* §§ 10505, 10505.5, 11460, 11463 (regarding county-of-origin and watershed protections). **Relatedly, the SWRCB can "require mitigation of potential economic impacts of a transfer that requires . . . [its] approval pursuant to the Board's broad authority to consider the public interest when administering water rights."** Water Transfers and the Delta Plan, *supra* note 59, at 9 (citing Cal. Water Code § 1253).

443 **According to state agencies with water transfer approval responsibilities, water transfers "based on reservoir storage releases, substitution of groundwater for surface water diversions, and crop idling . . . represent the bulk of water transfers within California to date."** Transfer History, *supra* note 57, at 2. **Although "Crop shifting and water conservation measures can also be used to develop water for transfer," these types of transfers are uncommon.** *Id.*

444 2016 Water Transfers White Paper, *supra* note 77, at 9.

445 2016 Water Transfers White Paper, *supra* note 77, at 9.

446 Cal. Dep't Water Resources, Information Requirements for Sellers Proposing to Transfer Water Made Available Through Crop Idling 1–2 (2016), *available at* http://www.water.ca.gov/watertransfers/docs/Water_Transfers_Crop_Idling_Checklist.pdf. **Information required about historical cropping includes the total acreage, farmable acreage, acreage by crop, double-cropped acreage and crops, acreage fallowed and why, non-irrigated cropped acreage, participating owners or growers, proposed crop for transfer year (if proposal includes crop shifting).** *Id.* at 1.

447 2016 Water Transfers White Paper, *supra* note 77, at 23.

448 2016 Water Transfers White Paper, *supra* note 77, at 23.

449 2016 Water Transfers White Paper, *supra* note 77, at 23–37; *see also* Cal. Dep't Water Resources, Information Requirements for Sellers Proposing to Transfer Water Made Available Through Groundwater Substitution 1–2 (2016), *available at* http://www.water.ca.gov/watertransfers/docs/Water_Transfers_Groundwater_Substitution%20Checklist.pdf. **DWR uses the following formula to calculate the amount of surface water available for transfer: Transfer-year groundwater substitution pumping – Baseline groundwater pumping – Estimated streamflow reduction.** *See* 2016 Water Transfers White Paper, *supra* note 77, at 28.

450 Cal. Water Code § 1745.10. **"[I]f a groundwater management plan has not been adopted," the water supplier must "determine[] that the transfer will not create, or contribute to, conditions of long-term overdraft in the affected groundwater basin."** *Id.* § 1745.10(b).

451 2016 Water Transfers White Paper, *supra* note 77, at 39.

452 2016 Water Transfers White Paper, *supra* note 77, at 39. **This includes at least five years of reservoir operating data including end-of-month storage, end-of-season storage, historical and forecast monthly inflows and water demands, historic releases, instream requirements, flood control diagram, reservoir area-capacity curve (if available), and any end-of-season target carryover storage.** *Id.*; *see also* Cal. Dep't Water Resources, Information Requirements for Sellers Proposing to Transfer Water Made Available Through Reservoir Reoperation 1 (2016) [hereinafter Information for Reservoir Reoperation], *available at* http://www.water.ca.gov/watertransfers/docs/Water_Transfers_Reservoir_Reoperation_Checklist.pdf.

453 2016 Water Transfers White Paper, *supra* note 77, at 39; *see also* Information for Reservoir Reoperation, *supra* note 452, at 1.

454 2016 Water Transfers White Paper, *supra* note 77, at 39–40; *see also* Information for Reservoir Reoperation, *supra* note 452, at 1.

455 *See, e.g.,* Lawrence H. Goulder, *Markets for Pollution Allowances: What Are the (New) Lessons?*, 27 J. Econ. Perspective 87, 89–90 (2013) (concluding that "[t]he promise of keeping aggregate pollution within the stipulated overall cap has been fulfilled in most of the cap-and-trade systems introduced for air pollution control" and that they show costs savings "relative to the same regulation without trading"); Ralf Martin et al., *The Impact of the European Union Emissions Trading Scheme on Regulated Firms: What is the Evidence after Ten Years?*, 10 Rev. Envtl. Econ. & Pol'y 129 (2015). *But see* Goulder, *supra* this note, at 90, 100 (stating that "[t]he international-level use of cap and trade to limit greenhouse gas emissions has been limited by difficulties in enforcement").

456 *See, e.g.*, Lauraine G. Chestnut & David M. Mills, *A Fresh Look at the Benefits and Costs of the US Acid Rain Program*, 77 J. Envtl. Mgmt. 252, 252 (2005) ("The SO_2 program is a departure from previous regulatory approaches because it sets an overall emissions cap and allows trading of emissions allowances between facilities, thereby creating flexibility for the regulated entities to find the lowest cost approach to reducing total emissions.").

457 *See, e.g.*, Sam Napolitano et al., *The NO_x Budget Trading Program: A Collaborative, Innovative Approach to Solving a Regional Air Pollution Problem*, The Electricity J., Nov. 2007, at 65; *Ground-Level Ozone (Smog) Information*, U.S. Envtl. Prot. Agency, https://www3.epa.gov/region1/airquality/ (last updated Feb. 23, 2016) (explaining that "[g]round-level ozone is formed by a chemical reaction between VOCs [(volatile organic compounds)] and oxides of nitrogen (NO_x) in the presence of sunlight").

458 *See, e.g.*, Alexandre Kossoy et al., State and Trends of Carbon Pricing 2015, at 11 fig.1 (2015), *available at* http://www.worldbank.org/content/dam/Worldbank/document/Climate/State-and-Trend-Report-2015.pdf (identifying 21 national-level and 22 subnational-level greenhouse gas emissions trading systems implemented or scheduled for implementation).

459 *See* Alice Kaswan, *Decentralizing Cap-and-Trade? State Controls Within a Federal Greenhouse Gas Cap-and-Trade Program*, 28 Va. Envtl. L.J. 343, 351 (2010) ("Trading programs focus on achieving an aggregate goal cost-effectively, not on the distribution of emissions. That feature may appear irrelevant in the GHG context, as the most prevalent GHG from stationary sources, carbon dioxide, does not have local environmental consequences. However, carbon dioxide emissions are almost always accompanied by more hazardous co-pollutants. Particulates, sulfur oxides, nitrogen oxides, volatile organic compounds, benzene, and mercury are common co-pollutants.").

460 Alice Kaswan notes that "[t]he distributional consequences of cap-and-trade programs are inherently uncertain; . . . even though emissions will go down in the aggregate, they could stay the same or even increase at facilities that choose to buy more compliance instruments." Alice Kaswan, *Climate Change and Environmental Justice: Lessons from the California Lawsuits*, 5 San Diego J. Climate & Energy L. 1, 24, 26–27 (2013–14) (explaining that "environmental justice advocates seek to maximize []pollutant reductions and their benefits, not simply prevent []pollutant increases" and that they "contend that the failure to maximize pollution reductions in the state's most polluted areas could continue the legacy of unequal exposure"); *see also* Noga Morag-Levine, *The Problem of Pollution Hotspots: Pollution Markets, Coase, and Common Law*, 17 Cornell J. L. & Pub. Pol'y 161, 164 (2007) (stating that, while "under technology standards, the hotspot is an artifact of feasible pollution control technology or locational clustering, . . . varying levels of air quality are hardwired into the design of [emissions trading," making "[l]ocally uncontrolled air pollution at a given location . . . a plausible outcome"). **"Hundreds of studies have now documented unequal exposures by race, ethnicity, and economic class."** Paul Mohai, David Pellow & J. Timmons Roberts, *Environmental Justice*, 34 Ann. Rev. Env't & Res. 405, 405, 425 (2009); *see also, e.g.,* Mary B. Collins, *Risk-Based Targeting: Identifying Disproportionalities in the Sources and Effects of Industrial Pollution*, 101 Am. J. Pub. Health S231, S231 (2011); Marie Lynn Miranda et al., *Making the Environmental Justice Grade: The Relative Burden of Air Pollution Exposure in the United States*, 8 Int'l J. Envtl. & Res. & Pub. Health 1755, 1755 (2011).

461 *See generally* Werner Antweiler, *Emission Permit Trading for Air Pollution Hot Spots*, Envtl. Econ. Pol'y Studies (2015), doi:10.1007/s10018-015-0138-x; *cf.* Stephen P. Holland & Michael R. Moore, *Market Design in Cap and Trade Programs: Permit Validity and Compliance Timing*, 66 J. Envtl. Econ. & Mgmt. 671,676–77 (2013) (discussing spatial restrictions on permit validity and permits-to-emissions compliance ratios); Meredith Fowlie & Nicholas Muller, Market-Based Emissions Regulation When Damages Vary Across Sources: What are the Gains from Differentiation?, at 1–2, 30–31 (2013), *available at* https://nature.berkeley.edu/~fowlie/Fowlie_Muller_submit.pdf (suggesting that differentiation is likely to reduce compliance costs when information about "emissions damage and abatement costs" is good and likely to increase compliance costs when there is substantial uncertainty).

462 *See generally* Michael Wara, *Instrument Choice, Carbon Emissions, and Information*, 4 Mich. J. Envtl. & Admin. L. 261 (2015); Andrew J. O'Connell, *A Critical Analysis of Allowance Allocation in Cap-and-Trade and Its Effect on Linked Carbon Markets*, 44 Tex. Envtl. L.J. 339 (2014); Alan Ramo, *The California Offset Game: Who Wins and Who Loses?*, 20 Hastings W.-N.W. J. Envtl. L. & Pol'y 109 (2014); David Takacs, *Protecting Your Environment, Exacerbating Injustice: Avoiding "Mandate Havens"*, 24 Duke Envtl. L. & Pol'y F. 315 (2014).

463 *See* Martin W. Doyle et al., *Optimizing the Scale of Markets for Water Quality Trading*, 50 Water Resources Res. 7,231, 7,232 (2014) (describing the possibility of trading between pollution sources assigned individual waste load allocations for impaired water bodies for which total maximum daily loads (TMDLs) have been developed under the Clean Water Act in the United States); Shortle, *supra* note 83, at 58, 59 tbl.1 (noting the development of water-quality-trading programs in the United States, Australia, Canada, and New Zealand); James Boyd et al., *Trading Cases*, 37 Envtl. Sci. & Tech. 217, 219–20 (2003). *But see* Goulder, *supra* note 455, at 90, 100 (concluding that "[t] he application of cap and trade for control of water pollution has been limited by difficulties of tracking the nonpoint sources, particularly the water pollution generated by the agricultural sector").

464 *See, e.g.,* Andrew Yates et al., *Market Power, Private Information, and the Optimal Scale of Pollution Permit Markets for North Carolina's Neuse River*, 35 Res. & Energy Econ. 256, 258 (2013) (describing "more flexible regulation" of the nitrogen-impaired Neuse River that allows "some trading between a group water treatment plants collectively called the Neuse River Compliance Association" and analyzing the optimal scale of pollution permit markets in the watershed); *see also* NRCA Nitrogen Transactions (Sales / Leases), Jan. 29, 2015, *available at* https://lnba.net/sites/default/files/NRCA%20Nitrogen%20Trades%202014.pdf (showing 30 trades between 2004 and 2014).

465 *See generally* World Resources Institute, Comparison and Effectiveness of Chesapeake Bay Nutrient Trading Program Policies (2015), *available at* http://www.usda.gov/oce/environmental_markets/files/ComparisonEffectivenessChesBayNutrientTradingPolicies.pdf.

466 *See* Yates et al., *supra* note 464, at 258.

467 *See* Doyle et al., *supra* note 463, at 7,232.

468 *See* Kurt Schnier et al., *Bilateral Oligopoly in Pollution Permit Markets: Experimental Evidence*, 52 Econ. Inquiry 1060, 1061, 1075 (2014) (suggesting that the costs of reduced trade in small markets tend to be cancelled out by the benefits of "fewer localized damage hot spots"); David A. Malueg & Andrew J. Yates, *Bilateral Oligopoly, Private Information, and Pollution Permit Markets*, 43 Envtl. & Resource Econ. 413 (2009) (concluding that "private information attenuates the effects of strategic behavior" in small markets).

469 James N. Sanchirico et al., *Catch-Quota Balancing in Multispecies Individual Fishing Quotas*, 30 Marine Pol'y 767, 767 (2006).

470 *See* James Acheson et al., *Individual Transferable Quotas and Conservation: A Critical Assessment*, Ecology & Soc'y, at *2 (2015), http://dx.doi.org/10.5751/ES-07912-200407 (summarizing a number of externalities and stating that "ITQs do not address many of the problems that need to be solved if fish stocks are to be made sustainable").

471 *See* Dale Squires et al., *Individual Transferable Quotas in Multispecies Fisheries*, 22 Marine Pol'y 135, 146 (1998) (describing "spillover effects," including (1) vessels selling ITQs for bluefin tuna in favor of participating in other fisheries and (2) increased "fishing effort and targeting" of "species not covered by ITQs but harvested in a multispecies fishery where some of the species are subject to ITQs"); *see also* Sanchirico et al., *supra* note 469, at 768 (stating that "[a]chieving the right balance between flexibility, overexploitation risk, and administrative simplicity is critical for the profitability and sustainability of multispecies fisheries").

472 *See* Squires et al., *supra* note 471, at 154 (arguing that "comprehensive species coverage by ITQs" may be the best approach for many multispecies fisheries, "promot[ing] widespread reduction of incentives for the race to fish"); *see also* Ragnar Arnason, *Economic Instruments for Achieving Ecosystem Objectives in Fisheries Management*, 57 ICES J. of Marine Sci. 742, 750 (2000).

473 *See* Dan Holland & Kurt E. Schnier, *Individual Habitat Quotas for Fisheries*, 51 J. Envtl. Econ. & Mgmt. 72, 73 (2006); Daniel S. Holland & Kurt E. Schnier, *Protecting Marine Biodiversity: A Comparison of Individual Habitat Quotas and Marine Protected Areas*, 63 Canadian J. of Fisheries & Aquatic Sciences 1481, 1482 (2006)

474 *See* Holland & Schnier, *supra* note 473, at 74–75; *see also generally* Daniel S. Holland & Kurt E. Schnier, *Modeling a Rights-Based Approach for Managing Habitat Impacts of Fisheries*, 19 Natural Res. Modeling 405 (2006); Holland & Schnier, *supra* note 473, at 1481.

475 *See* Parzival Copes & Anthony Charles, *Socioeconomics of Individual Transferable Quotas and Community-Based Fishery Management*, 33 Agric. & Res. Econ. Rev. 171, 176–77 (2004); Acheson et al., *supra* note 470, at *2; *see also generally* Svein Jentoft, *The Community: A Missing Link of Fisheries Management*, 24 Marine Pol'y 53 (2000) (discussing the role of fishing communities in fisheries management).

476 *See* Copes & Charles, *supra* note 475, at 176–77. **When a fishery transitions to a quota system, the number of vessels participating shrinks dramatically.** *See id.* 351; *see also* Kurt. E. Schnier & Ronald G. Felthoven, *Production Efficiency and Exit in Rights-Based Fisheries*, 89 Land Econ. 538, 540 (2013) (concluding that "the more inefficient a vessel is relative to others within the fleet, the more likely it is that it will exit the fishery when consolidation occurs"). **When catch is consolidated to fewer vessels, fewer fishermen are employed.** *See* Joshua K. Abbott et al., *Employment and Remuneration Effects of IFQs in the Bering Sea/Aleutian Islands Crab Fisheries*, 25 Marine Resource Econ. 333, 334 (2010). *id*. at 351 (noting, however, that "[t]he amount of time spent in onerous non-fishing activities—including time in transit to the grounds and gearing up/down for the season—has unequivocally fallen, as the consolidation of quota on fewer vessels has reduced the need for this redundant employment"). **Similar trends might be expected for those employed in the processing sector.** *See generally* Scott C. Matulich et al., *Toward a More Complete Model of Individual Transferable Fishing Quotas: Implications of Incorporating the Processing Sector*, 31 J. Envtl. Econ. & Mgmt. 112 (1996) (discussing the issues and potential options); Scott C. Matulich & Murat Sever, *Reconsidering the Initial Allocation of ITQs: The Search for a Pareto-Safe Allocations Between Fishing and Processing Sectors*, 75 Land Econ. 203 (1999).

477 *See BSAI Crab Rationalization*, NOAA Fisheries, https://alaskafisheries.noaa.gov/fisheries/bsai-crab-rationalization (last visited Sept. 28, 2016).

478 *See* Karly McIlwain & Jos Hill, Catch Shares in Action: United States Bering Sea and Aleutian Islands Crab Rationalization Program 7–9 (2013), *available at* http://fisherysolutionscenter.edf.org/sites/catchshares.edf.org/files/US_BSAI_Crab_Rationalization.pdf.

479 *See id.* at 7–8.

480 *See id.* at 7–8.

481 *See id.* at 6.

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