Groundwater Markets: Recommendations to Ensure Drinking Water Protections for Communities

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Introduction - Groundwater Markets and Drinking Water Sources

Through the implementation of the Sustainable Groundwater Management Act (SGMA), local groups called Groundwater Sustainability Agencies (GSAs) are tasked with managing their groundwater basins sustainably and addressing groundwater overdraft — which occurs when more groundwater is pumped out of the aquifer than is replenished either by rain, snow melt, or through recharge basins. In order to do this, GSAs will develop Groundwater Sustainability Plans (GSPs or plans) that specify how they will sustainably manage groundwater in their areas.

Under SGMA, sustainability is defined as avoiding unreasonable impacts of these six undesirable results: chronic lowering of groundwater levels, degraded water quality, depletion of interconnected surface water, reduction of groundwater storage, seawater intrusion, and land subsidence. GSPs will address three major components: 1) description of the plan area and basin setting, 2) defining sustainability criteria, and 3) projects and management actions which will help the GSA achieve the goals indicated under sustainable criteria, including projects, management actions, mitigation measures, and monitoring plans.[1] GSPs will be submitted in 2020 and 2022 (depending upon basin prioritization) to the Department of Water Resources (DWR) who will be reviewing and approving or disapproving GSPs.

SGMA is likely to result in significant changes in historical pumping patterns through the many management actions and projects that will be implemented over the next 20 and more years. One potential management action and project, and focus of this white paper, is to develop a system to trade groundwater pumping allocations.[2] Though the trading or transfer of surface water is a fairly common practice, trading groundwater is a newer endeavor in California that requires the development of thoughtful frameworks and rules to ensure that all groundwater-dependent communities are protected.[3]

In the Southern San Joaquin Valley, over 95 percent of residents depend on groundwater for at least part of their drinking water supply and many communities are entirely reliant on groundwater as their drinking water source.[4]

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Further, California's Human Right to Water law states that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and

[1] *See www.groundwaterexchange.org for more information on the components of a GSP (URL: https://groundwaterexchange.org/developing-a-groundwater-sustainability-plan/).*

[2] *The first pilot groundwater market under SGMA was launched by Fox Canyon Groundwater Management Agency in Ventura County in 2019. For more information, see: SGMA's First Groundwater Market: An Early Case Study from Fox Canyon (URL: https://groundwaterresourcehub.org/groundwater-markets/).*

[3] *While this paper solely focuses upon the impacts to drinking water supplies, markets must also be designed to protect other beneficial uses such as groundwater-dependent ecosystems.*

[4] *Carolina Balazs et al. Social Disparities in Nitrate-Contaminated Drinking Water in California's San Joaquin Valley, Environmental Health Perspectives, Vol. 119, pgs. 1272-73 (2011) (URL: https://perma.cc/JX8V-DHXC).*

[5] *Water Code §106.3.*

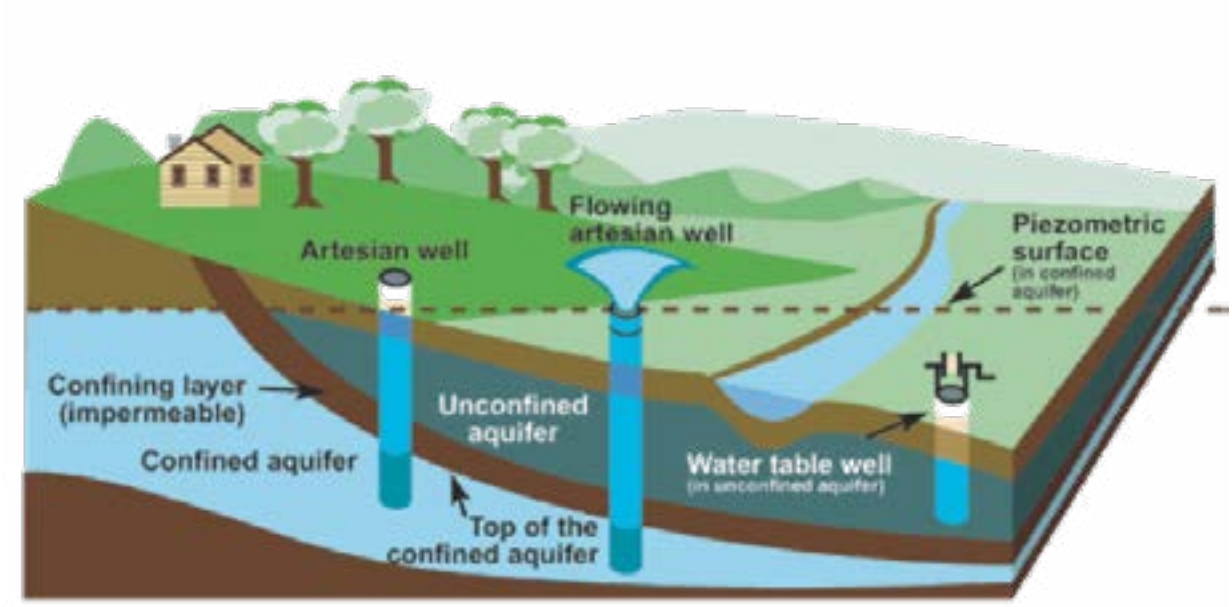

Figure 1 Source: Environment and Climate Change Canada

sanitary purposes".[5] While this does not apply directly to GSAs, it does apply to DWR. Therefore, before any management action or project is implemented, including a groundwater market, it is important for GSAs to consider the possible implications and proactively plan to avoid or mitigate impacts to communities dependent on groundwater supplies.

Historically, many low-income rural communities have struggled with access to safe and affordable drinking water and a well-run market can assist, though not solve, in addressing this issue. However, negative impacts are also possible and must be avoided or mitigated. Often those most vulnerable to the negative impacts from groundwater management decisions are those reliant upon shallow wells, including communities reliant upon domestic wells.

These same stakeholders often lack the financial resources to secure additional sources of water through means such as by purchasing additional rights to pump groundwater or surface water supplies to meet basic needs.

The purpose of this white paper is to:

1. Provide an overview of some of the major elements to consider when developing a well-designed groundwater market.

2. Introduce tools to help community stakeholders engage in the market design and implementation process.

3. Hold decision makers accountable in developing groundwater management strategies that are protective of community needs.

This white paper prioritizes key recommendations for the protection of drinking water sources where groundwater markets are adopted.

What is a Groundwater Market?

Groundwater markets, also referred to as "groundwater exchanges," "groundwater trading," or "groundwater sharing," facilitate the transfer of groundwater between users. Compared to top-down regulatory approaches, trading programs can provide groundwater users with more choices and flexibility on a voluntary basis to meet groundwater management objectives.

To develop a groundwater market, GSAs will first establish a total cap on pumping for their entire jurisdiction that is related to the sustainable yield of the basin, which is the amount of groundwater that can be pumped without causing undesirable results. Once the sustainable yield and total cap of pumping is established, the GSA would then assign individual pumping allocations defining how much groundwater each user in their GSA can pump. In a groundwater market, users who are not pumping their full groundwater allocation can sell their pumping allocations to another user who wants to pump more groundwater than their allocation provides.

Unlike surface water markets where surface water is traded and physically conveyed via canals and ditches from one water user to another, groundwater markets allow users to trade the ability to pump additional groundwater — not necessarily physically trading or moving groundwater. Thus for most groundwater trades what is actually traded are the permits or allocation to pump it. To enable this trading and ensure it is both effective and open to all users, the GSA will need to establish trading rules, design and implement a system to facilitate trading (e.g., bulletin board, online trading platform), and designate someone to oversee the trading. Ideally, the GSA would also provide reliable information on resource and market conditions. To gain buy-in and inform the design of the groundwater market, GSAs need to conduct extensive outreach and education to all groundwater users, ensuring that stakeholder input is solicited and actively considered in the design of the market.

Unlike surface water markets where surface water is traded and physically conveyed via canals and ditches from one water user to another, groundwater markets allow users to trade the ability to pump additional groundwater— not necessarily physically trading or moving groundwater.

How groundwater markets impact drinking water supplies depends upon how the market and the GSP as a whole are structured and implemented. A poorly designed market can result in negative impacts to both quantity and quality of supply, whereas a well-managed market can not only protect but improve drinking water supplies. Both the benefits and harms are discussed in more depth in the sections below. It is not the intent of this white paper to advocate either for or against markets, but to provide knowledge and resources to create a market that is protective of drinking water needs, should a GSA decide to implement one.

Understanding the Potential Harms and Benefits of a Groundwater Market

As an initial matter, it is important to note that GSPs are the foundation upon which management actions can be developed. If the GSP does not sufficiently address drinking water needs, then implementation measures, including a groundwater market, cannot make up for these deficiencies. Whether a groundwater market leads to harmful or beneficial impacts

all depends on how the market is designed, governed, implemented, and what feedback mechanisms are included and utilized throughout the life of the market.

The foundation of a well-designed trading program requires a fair and adequate allocation of groundwater for drinking water uses, with built in mechanisms to ensure future water needs for domestic use are met prior to allocating water for trading purposes, and trading rules that avoid undesirable results as well as avoid or mitigate potential impacts to communities dependent on groundwater supplies. If these components are missing, the market can have significant negative impacts upon a community's drinking water supply. Some impacts include, but are not limited to: localized drying of community and domestic wells, increased contamination levels, or unaffordable water rates.

It is important to note that these impacts are not unique to groundwater markets and have occurred prior to SGMA. In the context of groundwater markets, there are several ways these impacts can occur. For one, if a groundwater market allows for concentrated pumping in areas in close proximity to shallow drinking water wells, there can be negative impacts. Groundwater pumpers, especially those with deeper wells and the financial resources to pump more, could create cones of depression that draw-down groundwater levels below the depth of nearby domestic wells (Figure 2). Cones of depression caused by localized pumping could also shift the direction of groundwater flow, leading to the movement of contaminant plumes that can affect drinking water wells (Figure 2). All of this could lead to unaffordable water rates due to treatment, the need for an alternative water source, increased energy costs to pump from deeper depth of groundwater, and the drilling of new wells.

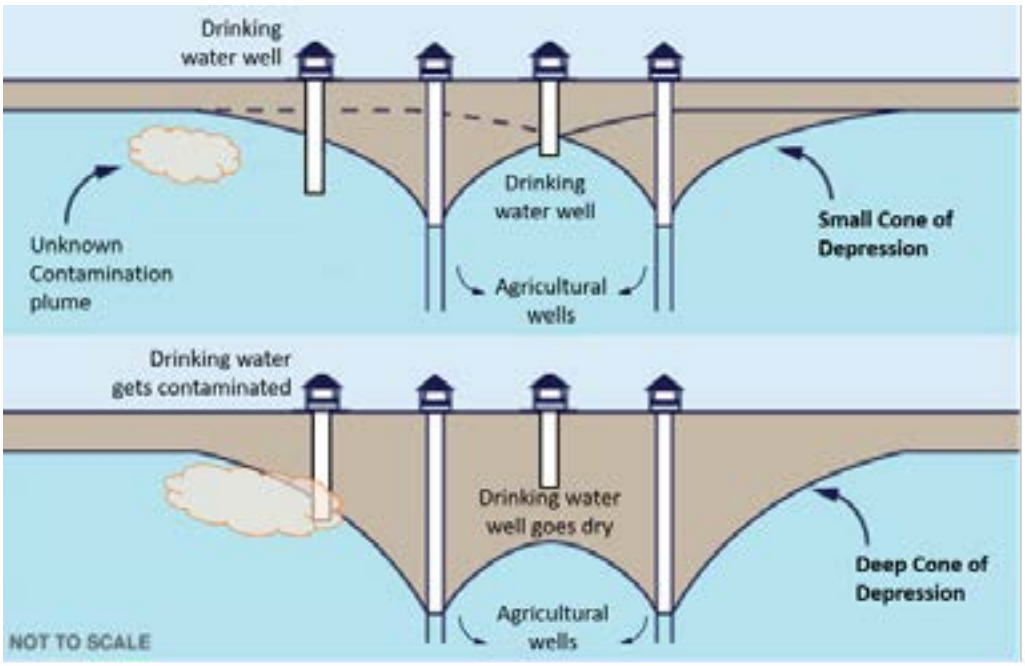

Figure 2: Deep agricultural wells create cones of depression that can cause drinking water wells to go dry and the movement of contaminant plumes. Source: Self-Help Enterprises

For example, when groundwater trading first began in the North Adelaide Plains area of South Australia, trades were concentrated in certain areas, severely drawing down local groundwater levels and prompting the introduction of special trading rules to mitigate the problem.[6]

[6] *Wheeler S.A., Schoengold K., Bjornlund H. (2016) Lessons to Be Learned from Groundwater Trading in Australia and the United States. In: Jakeman A.J., Barreteau O., Hunt R.J., Rinaudo JD., Ross A. (eds) Integrated Groundwater Management. Springer, Cham*

This experience highlights the need to devise groundwater trading rules that avoid and/or mitigate potential community impacts in the earliest stages of developing a groundwater market.

The foundation of a well-designed trading program requires a fair and adequate allocation of groundwater for drinking water uses, an additional margin for future growth prior to allocating water for trading purposes, and trading rules that avoid undesirable results as well as avoid or mitigate potential impacts to communities dependent on groundwater supplies.

While groundwater markets are often seen primarily as a potential solution to help groundwater users adapt to growing water scarcity and to lessen the economic burdens of reduced groundwater pumping on the agricultural industry, they also have the potential to benefit drinking water supplies when coupled with specific rules and strategies. Well-defined allocations for groundwater —along with a reliable, trusted system for exchanging those allocations — can potentially lead to the following benefits:

- Assurance that over-pumping does not occur in an area where domestic wells could go dry.
- The creation of protective areas, or management areas, where specific practices are required. Such areas could require stricter pumping restrictions or more beneficial projects such as recharge to improve groundwater quality.
- Incentivize projects that achieve multiple benefits, like groundwater recharge in areas sensitive to changes in groundwater levels (e.g. areas where shallow domestic wells exist). This could occur by reducing groundwater pumping allocations in such an area unless sustainability projects are implemented.
- Encourage conservation and the adoption of more efficient practices for all users of groundwater.
- Enable groundwater users to address conflicts in cooperative, transparent, mutually beneficial, and cost effective ways that can support local and regional long-term climate resiliency planning.

Community Water Center staff conduct testing of a private well.

Groundwater Allocations and Considerations for Equitable Distribution of Resources

Implementing groundwater allocations is often a necessary step in a strategy to help recover declining groundwater levels in overdrafted basins. Putting in place groundwater allocations can be a groundwater management strategy on its own; however, it is also a foundational component to implementing a well-functioning groundwater market. Users need to know how much groundwater they are allocated, so they know how much they are able to use or trade. The following are key criteria for community groups to consider in approaching the allocation process.

1. Establishing an extraction limit. Allocating groundwater involves first establishing a "cap", or limit, on how much groundwater can be pumped within the GSA and then allocating or assigning portions of this capped amount to individual groundwater uses and users. The groundwater cap is based on the sustainable yield of a basin, which is the "maximum quantity of groundwater that can be withdrawn annually from a groundwater supply without causing an undesirable result".[7] GSAs are required to determine the sustainable yield, or cap, in their GSPs.[8]

2. Understanding and accounting for groundwater user needs. In order to determine the sustainable yield of the basin and assign groundwater allocations, water managers need to have a clear understanding of the various groundwater users in their basin and the users' associated needs and demands for groundwater. This requires accounting for both current and future needs.

3. Understanding legal requirements. Water managers also need to understand the existing legal requirements and protections that are in place. Importantly, Water Code Section 106 declares that "the use of water for domestic purposes is the highest use of water," and the Human Right to Water[9] also exists to protect domestic water users. Additionally, SGMA does not create or adjust groundwater rights so the basic law of groundwater rights and priorities remain unchanged.[10] So, while SGMA puts forth a set of regulations to guide sustainable groundwater management within California, there are other existing laws and priorities that need to be considered when devising groundwater allocations.

4. Establishing a non-tradeable allocation for drinking water. Allocation is the assignment of available groundwater to various users within the basin. In order to best protect drinking water needs for communities, we recommend that GSAs establish a non-tradable allocation amount of groundwater as part of the calculation for the sustainable yield to adequately meet drinking water needs for public health and safety, including for drinking, cooking, and sanitary purposes. In order to determine this baseline for drinking water, GSAs will need to work with small community water systems, cities, and/or the county to determine current and future daily drinking water needs.

[7] *Water Code §10721 (w).*

[8] *This cap may reasonably be adjusted over time as the understanding of the basin improves and/or as additional recharge is provided. Calculated over a base period representative of long-term conditions in the basin and including any temporary surplus See Department of Water Resources. Best Management Practices for the Sustainable Management of Groundwater (URL: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Sustainable_Management_Criteria_2017-11-06.pdf).*

[9] *Water Code §106.3.*

[10] *See Babbitt, C. and D. Dooley, et al. Groundwater Pumping Allocations Under California's Sustainable Groundwater Management Act: Considerations for GSAs. Environmental Defense Fund (2018) (URL: https://www.edf.org/sites/default/files/documents/edf_california_sgma_allocations.pdf).*

5. Allocating groundwater. Once this non-tradeable allocation for drinking water is established, the remaining available groundwater can then be allocated to other groundwater pumpers for trading in the market. Larger cities with more resources and capacity might be interested in having a tradeable allocation depending on their specific drinking water situation. More information on tradeable drinking water allocations is shared in the following sections.

It is important to recognize that the crucial steps of setting the pumping cap and devising allocations can lead to real risks for communities and if their needs are not considered and accounted for. Approaches to determining allocations can span from distributing available groundwater equally among all overlying groundwater rights holders, to allocating an equal quantity of groundwater to each acre of land a right holder has, to allocations based on historic pumping. Unfortunately, there is no one-size-fits-all solution when it comes to how to best allocate groundwater.[11]

Regardless of the method used, establishing a pumping cap on groundwater use and assigning allocations requires data and information reflective of all water needs and uses within the basin, and yet our current knowledge of groundwater use and hydrogeology is often imperfect and insufficient to make well-informed management decisions. While an overall cap on pumping may be easier to finalize early on, there must be mechanisms within the allocation scheme that allow for flexibility to adjust over time to account for changing climatic conditions and incorporate new information.[12]

When groundwater allocation systems are being developed, stakeholders should pay close attention to the following:

- Does the GSA have an accurate understanding of the hydrogeology of the subbasin and how much water is flowing into and out of the system? This includes understanding annual variations due to water-year type (high, average, and low water years) as well as variations due to a changing climate.

- Does the GSA have an accurate understanding of community water needs, risks, and requirements? Is this information used to inform allocation decisions? For example, what is the water district's peak historical use? How many people are served by the water district? What drinking water quality standards need to be met?

- How are community needs accounted for in the allocation scheme? Is the amount of non-tradable drinking water allocations sufficient for community needs? How is community growth over the long-term considered?

- Are allocation decisions informed by the best available science on the hydrogeology of the basin and community stakeholder input? Where are there areas of uncertainty? What systems or requirements will be established to improve data availability? How can planning incorporate flexibility to address uncertainty?

- Are there clear periods in time and mechanisms for re-evaluating the allocations

[11] *Utilizing a comprehensive allocation approach that respects the law of groundwater rights increases the probability that the approach will be supported if tested in court. See McGlothlin, M. and J. Acos. The Golden Rule of Water Management, Golden Gate University Environmental Law Journal, Vol. 9, Issue 1 (2016) (URL: https://www.bhfs.com/Templates/media/files/The%20Golden%20Rule%20of%20Water%20Management.pdf). See also Szeptycki, L., E. Conrad, W. Blomquist, and J. Martinez. A Flexible Framework or Rigid Doctrine? Assessing the legacy of the 2000 Mojave decision for resolving disputes over groundwater in California. Stanford Environment Law Journal, Vol. 37, Issue 2 (2018) (URL: https://law.stanford.edu/publications/a-flexible-framework-or-rigid-doctrine-assessing-the-legacy-of-the-2000-mojave-decision-for-resolving-disputes-over-groundwater-in-california/).*

[12] *For example, in the Upper Republican Natural Resource District in Nebraska, allocations are adjusted every five years based on water availability, interstate compact compliance requirements, and crop water demands. See Babbitt, C., K. Gibson, et al, 2018. The Future of Groundwater in California: Lessons in Sustainable Management from Across the West (URL: https://www.edf.org/ecosystems/future-groundwater-california).*

in order to adapt to changing conditions? What are the mechanisms and how often does the market operator or GSP plan to re-evaluate the allocations? Is there a means to address allocations at other times, particularly when adverse impacts are becoming apparent?

Tradable Allocations

For many small, rural, low-income, or unincorporated communities, making sure that the GSA includes a non-tradeable allocation of groundwater as part of the sustainable yield will be important to protect their drinking water needs. For some communities, having their drinking water allocation be tradable could significantly impact their access to safe and affordable water.

Larger cities or communities with diverse drinking water resources may be interested in having their groundwater allocation be tradeable and may be able to do so in a way that adds to their water resiliency. There are a number of potential drawbacks and benefits to having a tradeable drinking water allocation and each city or community should involve stakeholders in the process of making that decision, particularly communities with shallow domestic wells that rely on groundwater for most or all of their drinking water needs.

A couple potential benefits include:

- Larger cities that decide to have a tradeable groundwater allocation can potentially generate revenue by leasing/selling their groundwater allocation in times when they have a surplus. This revenue could be used for a number of beneficial purposes, including providing a low-income rate assistance program for drinking water bills.
- This flexibility can benefit other resource users by providing additional supply, available through trades that benefit both parties.

A couple potential concerns:

- Potential for mismanagement that results in a community trading away a portion of their critical supplies and having to purchase additional allocations later on, resulting in high water rates.
- Issues surrounding the monetization of a resource that is essential to a basic human right.

Accounting for Adequate Community Growth

The population in the Central Valley ("Valley") is expanding; between 2017 and 2018, the Valley experienced its highest population growth at a rate higher than the Bay Area and Los Angeles.[13] Further, population grew at a staggering 44% between 1990-2009, while the state-wide population growth was 24%.[14] Given the steady growth of jobs in the agricultural sector[15] and the lack of affordable housing in Central Valley cities, population growth in rural disadvantaged communities may also continue to rise.[16]

With adequate GSPs, groundwater markets can be designed to protect precious drinking water resources for growing populations.

[13] *Lillis, R.. On the Rise? The Central Valley is Beating the Bay Area and L.A. in key measures. Sacramento Bee (2019) (URL: https://www.sacbee.com/news/state/california/big-valley/article223896300.html).*

[14] *California's Central Valley Finds Itself on the Political Map. PBS.Org (2010) (URL: https://www.pbs.org/newshour/politics/californias-central-valley-finds-itself-on-the-political-map).*

[15] *California Department of Agriculture. Table of Agricultural Employment (URL: ttps://www.labormarketinfo.edd.ca.gov/data/ca-agriculture.html).*

[16] *Bliss, L.. California's New Governor Would Punish Cities Over Affordable Housing. WWW.CITYLAB.COM (2019) (URL: https://www.citylab.com/transportation/2019/01/gavin-newsom-housing-reform-transportation-budget-homeless/580192/).*

With adequate GSPs, groundwater markets can be designed to protect precious drinking water resources for growing populations. GSAs must accurately calculate the amount of drinking water needed in all communities and cities within its borders, including those that exist today and in the future. Since groundwater management decisions impact drinking water supplies well into the future, decisions must be made based on reliable, trusted information about the drinking water needs across at least the next 20 years. Planning that accounts for such growth will avoid catastrophes such as dry wells and increases in drinking water contamination. Such planning can, and should, also include means for addressing and implementing conservation measures within communities that can over time reduce demand in a sustainable fashion that does not result in unaffordable water rates for low-income customers.

Tools for addressing community growth in GSPs:

- **Local land use planning documents:** GSAs can use local land use planning documents to learn how local agencies project future population growth. Cities and counties' general plans contain information about projected population growth, and show how local agencies will continue developing and where they intend to concentrate population growth in the future. General plans created or modified after 2012 must identify all disadvantaged communities in their jurisdiction, and include an analysis of drinking water issues in those communities. GSAs should reference this information to ensure they have identified all disadvantaged communities in their GSA area, and to ensure they can meet changing community drinking water needs. If a general plan does not have growth projections or identify disadvantaged communities, GSAs should look to local Regional Transportation Plans and Local Agency Formation Commissions' Municipal Service Reviews.

- **Regional Transportation Plans:** Required for local agencies to receive federal transportation funding, Regional Transportation Plans show local population projections as well as areas where local governments intend to build out transportation infrastructure to facilitate development and population growth. GSAs should also reference those planning documents to understand local development patterns and population projections.

- **Municipal Service Reviews (MSRs):** MSRs, done by Local Agency Formation Commissions (LAFCOs), contain information about current populations served by local agencies' drinking water services, issues with drinking water provision, and local agencies' intent for expansion of development and services. After July 1, 2012, LAFCOs must also identify all disadvantaged communities in their service area before they can approve a change in the agency's sphere of influence, and analyze whether they are or will be in need of drinking water, sewer, or fire suppression service.[17]

Residents come together for a community meeting on their local water resources.

[17] *Government Code §56425(e)(5).*

- **Work with local government and community groups:** If local general plans, regional transportation plans, and MSRs do not show population growth projections or identify disadvantaged communities, GSAs should work with local government and community groups: If local general plans, regional transportation plans, and MSRs do not show population growth projections or identify disadvantaged communities, GSAs should work with local city and county governments, local communities, and community-based nonprofits to identify disadvantaged communities and obtain information on population growth in all cities, small towns, and rural communities in the GSA area.

To effectively account for population growth in drinking water groundwater allocations, GSAs must plan to start with a baseline that accounts for existing drinking water consumption and consider how best to account for future growth over the next 20 years. This can include incrementally increasing drinking water supplies every five years according to actual or projected population growth and changes in population growth patterns as GSP implementation occurs. Further, the market and GSA should work with communities to develop and implement conservation practices, including water loss prevention and installing water efficient appliances or other technologies, which may overtime reduce the demand even as population increases.

Developing Trading Rules

There are a number of potential trading rules GSAs can consider when developing markets. UC Berkeley School of Law has developed a report on groundwater market that presents some examples of trading rules GSAs might consider, such as:

- Trading can occur only within hydrologically connected areas.
- Trading is prohibited when a sustainability indicator crosses a specified threshold.
- Unused portions of groundwater 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).
- Trading zones can be developed to increase the net social and environmental benefits of transfers of groundwater allocations. Specific transfer restrictions can apply to trading within a zone.[18]

[18] *Green, N., et al. Trading Sustainably: Critical Considerations for Local Groundwater Markets Under the Sustainable Groundwater Management Act. Center for Law, Energy & the Environment, UC Berkeley School of Law, pg. 90 (2017) (URL: https://www.law.berkeley.edu/research/clee/research/wheeler/trading-sustainably/).*

Tools to Protect Community Water Sources

A groundwater market can, for good or bad, impact groundwater levels and quality, and in turn influence affordability for domestic supplies. The results will depend on what tools and practices are integrated into the market. Below we highlight examples of potential strategies to protect community drinking water sources.

Management Areas: A GSA can create clear boundaries around a portion of the basin that may require special consideration. This management area may be created to protect a community's drinking water resource or any other use of the groundwater, with specific restrictions on pumping and trading. One example of a trade restriction may be to only allow trading within the area, or limit pumpers from purchasing extra credits outside of the management area, while still allowing them to sell their credits to outside pumpers. This ensures that no water is pumped beyond what is determined to be sustainable within the management area, protecting all uses and users of groundwater in the area and potentially avoiding localized impacts of dry wells or increased contamination.

Monitoring and setting triggers: A GSA can also dictate that additional monitoring is required near potentially vulnerable groundwater areas, like communities that rely on shallow wells. If triggers are met for groundwater levels or groundwater quality, restrictions must be implemented to prevent further harm to drinking water supplies. The use of triggers is discussed more in depth later in the "Adaptive Management" section of this white paper.

Routine monitoring is essential to ensuring negative conditions do not impact shallow wells. The device pictured here measures depth to groundwater. Source: Juliet Christian-Smith and Kristyn Abhold. Union of Concerned Scientists. Measuring What Matters. (2015)

Emergency drinking water mitigation plan: While local and county plans and historical pumping data should be used to determine community needs for their non-tradable allocation, there may still be unanticipated community needs that arise — particularly in the face of extreme weather conditions such as droughts or if caused by impacts directly related to the implementation of a groundwater market. In order to prevent negative impacts to residents' access to a reliable source of water for critical domestic needs, the GSA and the market administrators should develop an emergency drinking water mitigation plan to ensure adequate domestic supplies.

This emergency plan could entail providing the community a temporary additional pumping allocation to meet the critical shortage they are faced with or providing support for short-term emergency drinking water needs. While this additional emergency allocation may not be accounted for in the original determination of sustainable yield, preventing harm to public health

must be planned for. It is up to the GSA to determine how to account for where these shares would come from and how it possibly impacts sustainable yield.

In order to prevent negative impacts to residents' access to a reliable source of water for critical domestic needs, the GSA and the market administrators should develop an emergency drinking water mitigation plan to ensure adequate domestic supplies.

If a significant number of shares are necessary, a restructuring of how allocations are divvied up across the GSA may be called for. The emergency plan should include under what conditions a community may be eligible, how a community can apply, and any conditions tied to acquiring the additional allocation (such as implementing any additional conservation measures). If the community is already implementing conservation measures to the best of its ability, the community's base allocation may need to be revisited or the GSA/market operator should consider assisting the community in obtaining funding and implementing additional conservation measures to help ensure the original allocation amount is sufficient to meet community needs.[19]

Incentivizing Projects to Promote Drinking Water Resilience

While a well-designed market for pumping rights creates incentives to conserve water and reallocate its use, it alone does not incentivize all activities to improve other important resource conditions, such as groundwater quality. Groundwater markets can be leveraged to provide incentives for projects that benefit groundwater management outcomes, which could create an important strategy to help GSAs in meeting their goals under SGMA.

For example, in order to increase the water resilience of small and vulnerable communities, groundwater recharge projects can be implemented in key locations. Here, the GSA could offer compensation as an incentive for locating a recharge site near a community reliant on shallow drinking water wells. A closer location can help protect against declining aquifer levels and potentially improve groundwater quality conditions. However, as with any management strategy, it is important to understand any associated impacts within the broader context of SGMA to avoid each of the six undesirable results. In the case of recharge near drinking water wells, it is important to understand potential water quality implications as recharge can also flush contaminants into portions of the aquifer used for drinking water sources.[20] Nonetheless, this approach could increase the resilience of small communities to drought, possibly at a much lower total cost than could be achieved through other methods.

Two critical components of incentives for recharge projects are the type of payment that is provided and the way it is funded. One option for incentives is direct monetary compensation or payments that increase with the quantity of recharged water. In this case, a number of funding sources could be leveraged, including a pumping fee established by the GSA, the use of state resources, or a combination of the two. Alternatively, those who

[19] *For more information, see Community Water Center, Leadership Counsel for Justice and Accountability, Self-Help Enterprises. Framework and Guidance for Developing a Drinking Water Well Impact Mitigation Program (2020).*

[20] *See Fakhreddine, S., et al. Protecting Groundwater Quality in California: Management considerations for avoiding naturally-occurring and emerging contaminants. Environmental Defense Fund (2019) (URL: https://www.edf.org/sites/default/files/documents/groundwater-contaminants-report.pdf). See also, Guide to Protecting Groundwater Quality in SGMA. Community Water Center (2019) (URL: https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858).*

recharge near community wells could receive additional pumping credits instead of monetary compensation as long as the additional pumping credits do not negatively impact communities. In this case, a market can play an important role in making the pumping credits more valuable: in the absence of a market, only the entity undertaking recharge can use the additional credits, but if they are tradable, then this entity could benefit by transferring the credits to others.

However, a compensation approach that provides additional pumping credits would likely be complicated by the need to comply with overall pumping limits within the basin and would need to carefully consider the impacts to other pumpers. While having these types of pumping credits, incentives, and payments does not require a groundwater market, where monetary funds are difficult to mobilize, a market can help to make in-kind compensation (pumping credits) a more flexible and valuable form of incentive.

Critical questions when considering incentives and potential projects:

- Are there areas near communities within the GSA where it would be beneficial to consider a groundwater recharge project to improve groundwater quality and/or increase water levels?
- If funds are available, are there other projects that could improve water conservation efforts for communities within the GSA? For example, improving water treatment to use less water or water loss prevention.
- Are there opportunities for community water districts to strategically collaborate with the GSA, the county, landowners, or other partners to undertake a multi-benefit project and apply for state funding?

Monitoring Networks

Monitoring networks are an important and required component of SGMA – one that becomes even more important in areas where groundwater markets are considered. In areas where markets may emerge, a monitoring network should not only detect the status and trends of groundwater conditions, but must also be deployed to ensure that the market is running well and is not resulting in adverse impacts to groundwater quality and/or groundwater levels.

Monitoring should be designed to address concerns at multiple scales. At the individual well scale, monitoring is needed to measure groundwater use and elevations, and in some cases water quality. At the GSA scale, there should be a monitoring network throughout the GSA boundary to monitor groundwater levels, groundwater quality, subsidence and aggregate pumping across the basin (to ensure that use is well within the overall cap on groundwater extractions).

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All monitoring data should be centralized with a GSA administrator. The administrator could be the GSA or a third-party, whose role may include verifying the user's allocation, comparing groundwater use against the user's allocation, adjusting allocations for any trades that add to or reduce the allowable pumping volume, and/or reporting pumping volumes to the GSA. The monitoring system must be able to detect and prevent use or trading of groundwater that exceeds a user's allocation.

In areas around drinking water wells and/or where water quality is a concern, monitoring must detect and report changes in groundwater levels and contaminants of concern. This may require specialized monitoring (and well design) capable of characterizing conditions in the shallow aquifer where many domestic drinking water wells access supplies as well as deeper aquifers where municipal wells access supplies. Areas where drinking water is more vulnerable may require a higher density of monitoring points and/or more frequent data collection to detect seasonal fluctuations, impacts of trading, and other negative changes in groundwater conditions. With trading, there is a potential for negative impacts to these sensitive areas to occur faster because trading can increase pumping in these areas as local users purchase allocations.

To take advantage of existing water quality monitoring, GSAs should develop coordination and/or data sharing agreements with local cities and small communities. The monitoring network could also be used by the GSAs to assess fees on individual pumpers based on pumping volumes. If the current monitoring wells are insufficient to capture data on these conditions, then the GSP should identify these gaps in data and make a plan to address the monitoring needs, including a timeline for action and firm funding sources.

Critical questions when developing monitoring networks:

- Are there any contaminants in communities within the GSA that are close to exceeding the limits for any drinking water contaminant standard and where it would be appropriate and feasible to choose a minimum threshold below the drinking water standard?

- Are there areas within the GSA with domestic wells that have gone dry in the past? If so, what year did they go dry and how deep were the wells?

- Are there areas that would be strategic to add more monitoring wells?

Establishing Triggers and Implementing Solutions

Developing a protective warning system, or triggers, can alert groundwater managers when groundwater levels are dropping, or if the groundwater quality is worsening to a level that negatively affects drinking water users. As a part of developing a GSP, GSAs are required to establish interim milestones that ensure they are on track to meet their measurable objectives and avoid surpassing their minimum thresholds. Regardless of whether a GSA utilizes a market system, such triggers are essential for groundwater management, but can be adjusted to fit the needs of different management actions as well as the basin as a whole. The table below provides an example of what a warning system might look like, using green, yellow, and red light indicators or “triggers”, and some potential corrective actions groundwater managers can undertake to remedy the problem.

Triggers	Groundwater Status	Potential Corrective Actions
Greenlight	Groundwater levels and quality are stable and the market may continue.	No action required.
Yellow light	Groundwater levels and quality are approaching concerning levels and impacts may occur or are occurring at a low rate. Some corrective actions are needed.	- Undertake an analysis to pinpoint the cause. - Inform both the specific groundwater users (where it is feasible to identify those users) who caused the trigger and those who are impacted by the trigger status. - Provide support to groundwater users experiencing impacts. - Reassess pumping allocation and consider restricting or limiting groundwater extraction near the triggered area.
Red-light	Time to stop and mitigate as significant impacts are imminent or are occurring.	- Stop groundwater trading near impacted groundwater users. - Provide interim emergency solution while pursuing a permanent solution to impacted groundwater users (see examples of interim and long-term solutions in the table below).

Ultimately, this approach allows for an evaluation of what is happening and reacting accordingly to prevent or mitigate negative impacts. Groundwater markets should be managed to avoid reaching a 'red-light' trigger. However, if negative impacts do occur, interim and long-term solutions are crucial to prevent further lowering of groundwater. While a permanent solution is pursued, interim solutions serve to address the immediate impacts and ensure access to safe drinking water. The table below provides examples of interim and long-term solutions.

Solution	Problem	Options	Implications of Utilization of this Solution	Estimate of Costs[21]	
Interim Solution	Water Quality	Point-of-Use	Treats a portion of water used in the house. Less likely to be maintained, and assistance must be provided until a long-term solution is implemented. Costs estimates include installation, sampling, and filter.	$1,000 to $1,500 / unit / home.	
		Bottled water	An effective and reliable source of safe drinking water, and may be the only option available depending upon contaminant concentrations. However, bottled water can be expensive over a long period of time and comes with distribution challenges.	$30 to $50 / month / house, including delivery.	
	Access to Water	Water tank program with bottled water	Tanked water can meet basic sanitation needs but should not be used to meet drinking water needs. Instead, the program must be paired with delivery of bottled water to address drinking water needs.	- 2,600-gallon water tank and materials roughly $2,100. - Labor and tank Installation $1,500, does not include mileage. - Electrical permit $80, depending on county. - Tank water between $300 to $500 depending on delivery charge by water hauler, per load or per hour. - $30 to $50 per month per house, includes delivery.	
Permanent Solution	Water Quality	Water treatment system	Technical, managerial, and financial capacity of the community should be considered when assessing water treatment options.	Costs vary depending on the technology, water contaminant(s), and number of households.	
		Alternate supply source	Options include surface water, construction of a new well, and consolidation with a nearby water system.	Costs vary depending on the desired solution, technology, and number of households.	
	Access to Water	Lowering of well pump	Least expensive long-term solution, if conditions allow. The following factors should be taken into account: lowering of a pump in the well is limited by the depth of the well, pumps near the base of the well increases energy consumption, may require more frequent screen cleaning, and water quality may be degraded due to sediments that are drawn in.	Costs vary depending on the well condition, type, and depth.	
		Drill a new deeper well	A well test is necessary to assess yield capacity and water quality on deeper levels.	Private wells	$20K to $45K.
				Water systems	Up to $1.5M.
		Alternative water supply source	Options include surface water or consolidation with a nearby water system. Consider consolidation when households understand and agree with the implications of connecting to a local water system.	Costs vary depending on the desired solution, technology, and number of households	

[21] *Costs are estimates based on Self-Help Enterprises' experience in providing interim and permanent solutions to disadvantaged communities in the San Joaquin Valley during the 2012-2014 drought. Costs are provided for illustrative purposes only and should be considered as rough estimates.*

Lastly, to achieve a successful mitigation plan that benefits all water users, it is important to engage all groundwater users to help develop the market's value-driven planning objectives, evaluate impacts, identify mitigation options, and collaborate in a transparent process so that all parties understand and agree on the proposed water market. Building strong partnerships with other programs and organizations can also support leveraging resources and facilitate the development of projects and programs that maintain or improve groundwater quality and quantity.

Case Study: Kern County Well Mitigation Strategy

Rosedale Rio-Bravo Water Storage District, Kern County Water Agency, Pioneer Project Recovery Participants, and Kern Water Bank Authority.

Since the concept of groundwater trading or markets is relatively new, we must look to other similar projects for guidance. One such example is the Kern County Well Mitigation Strategy which includes tools for both identifying potential harmful impacts caused by management actions and how to mitigate or rectify those impacts.

The agencies listed above developed a program designed to prevent, eliminate or mitigate significant adverse impacts caused by their groundwater banking operations. This program utilized a groundwater model to: forecast how groundwater levels could change based on potential project impacts, identify at-risk domestic wells, identify areas for additional monitoring, and determine if monitoring triggers have been met. If a well goes dry, an analysis using the groundwater model is used to determine if the well failure was caused by the district's groundwater banking operations. If the well failure was caused by the district's actions, the district is committed to implementing a combination of the following:

- Providing short term emergency water supply to domestic well owners.
- Providing funds to lower well pump or drill a deeper well.
- Providing funds to connect to a water provider.
- Providing an alternative water supply.
- Reduce recovery pumping as necessary to avoid the impact.

GSAs could consider implementing a similar type of mitigation strategy for wells that go dry due to groundwater management activities, including groundwater markets.

Source: Project recovery operations plan regarding pioneer project for the Rosedale-Rio Bravo Water Storage District and Kern Water Bank Authority projects (2017).

Stakeholder Engagement

In order to effectively aid in managing groundwater resources, a groundwater market must have the confidence of its participants and the larger community. Transparency and stakeholder engagement can both lead to higher levels of trust in a system, as well as better outcomes for all participants.

Stakeholder engagement is premised on the concept that people have a right to be involved in decision-making processes that affect them. Especially in the case of a shared resources like groundwater, where collective action is needed to manage the supply sustainably, involvement of affected stakeholders is critical to successful plan implementation. Diverse stakeholders bring a wealth of information to the table, both in terms of data and lived experience. By increasing the level of understanding of regional issues and fostering collaboration to identify potential problems and solutions, stakeholder participation can increase buy-in to a market and its effectiveness as a shared tool. Without effective long-term stakeholder engagement, a market may be more likely to experience worse outcomes, externalities that were not foreseen and thus higher costs to mitigate those externalities, litigation, and greater conflict. Community input is especially critical in the following stages of developing and implementing a GSP that includes a groundwater market:

- Gathering information to calculate water budget and water needs.
- Identifying groundwater allocations that adequately address community needs now and into the future.
- Identifying potential positive or negative impacts from groundwater markets.
- Identifying community needs and ensuring fair water distribution and access within the community.
- Monitoring groundwater trading programs to assure it is avoiding adverse effects on drinking water.

SGMA recognizes the value of stakeholder engagement, and has numerous requirements to ensure "the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin".[22]

In order to conduct effective outreach to design and implement groundwater markets, GSAs should follow the requirements of the Brown Act[23] and the Bilingual Services Act,[24] and implement best practices for public engagement, including but not limited to:

- Host public workshops to keep the public consistently informed and take proposals to the public before decisions are made.
- Ensure that public workshops are in the evening, in a location accessible to a wide variety of stakeholders (such as close to public transit), provide food and childcare.
- Provide interpretation at all public meetings and translate all materials into threshold languages.
- Agendize and notice all public meetings and provide meeting materials before each meeting.
- Ensure that outreach for workshops is done in a way that is accessible and effective for all beneficial users. Door-to-door outreach is most effective for communities with potentially limited access to the internet.

[22] *Water Code §10727.8(a).*
[23] *Government Code §54950 et seq.*
[24] *Government Code §7290 et seq.*

- Work with local community-based nonprofits to conduct outreach and design workshops in a way that is accessible to all types of beneficial users, including disadvantaged communities.

- Ensure that input gleaned at meetings and public workshops is meaningfully considered and incorporated into groundwater market design and implementation.

For members of the public, there are many ways to get informed of and participate in decision-making processes your GSA may be undertaking, including the decision to create or join a groundwater market. Engage early and often!

Below are some opportunities to get involved:

- Put your name on the "interested parties" list to receive notifications of decisions the GSA is considering.

- Encourage your GSA to adopt transparent data sharing platforms, such as a public-friendly trading website.

- Attend public meetings and enter your feedback in the written record during public comment periods.

- Work with local community-based organizations like Self-Help Enterprises, Leadership Counsel for Justice and Accountability, and the Community Water Center to stay informed and ensure that your community's needs are represented in the decision-making process.

Local community water leaders discuss groundwater plans at workshop.

A Wrap-Up: Recommendations and Closing

It is important to note that every community is slightly different, so a water trading program for one region may not work for another. This is because of differences in geography, land use, population size, local water conditions, and water contamination in the area. Each region's GSP should address these localized differences and needs. Markets cannot succeed absent an inclusive GSP that provides for drinking water.

As GSAs develop rules to govern groundwater under SGMA, they must take into account the impacts that can arise from pumping groundwater, both for local use and groundwater transfers. It is important to recognize that groundwater markets are not a panacea to address all groundwater management issues. These market tools will only lead to sustainable groundwater management if they are designed in a manner that addresses the potential adverse social, economic, and environmental impacts that can result from groundwater trading.

These market tools will only lead to sustainable groundwater management if they are designed in a manner that addresses the potential adverse social, economic, and environmental impacts that can result from groundwater trading.

As such, there is a critical need for thoughtful approaches to establish groundwater trading systems and markets that are comprehensive and fairly manage groundwater demand and use. These tools must incorporate mechanisms to protect against and mitigate potential adverse impacts while being efficient, transparent, and predictable.

Here are some recommendations for developing water trading programs designed to ensure community drinking water protections:

- Engage community in a timely manner throughout market design and implementation.
- Ensure that community drinking water needs are recognized and accounted for when groundwater allocation systems are established. We recommend community drinking water needs to be included in the sustainable yield calculation that GSA are required to produce. GSAs should establish a non-tradeable allocation of groundwater to adequately meet public health and safety, as well as drinking water needs, and build in mechanisms to ensure future water needs for domestic use are met.
- Leverage local general plans, regional transportation plans, municipal service reviews, and the expertise of local government and community groups to help identify the current and future water needs of a community.
- Explore the role that management tools (e.g., management areas) and incentive-based strategies (e.g. incentivizing groundwater recharge to improve groundwater levels and quality near shallow wells) can play to ensure and/or reward actions that achieve groundwater management goals.
- Consider conservation practices and the role they can play in both allocation strategies and market mechanisms.
- Ensure that monitoring networks are in place to detect the status and trends of groundwater conditions, and to ensure that the market is

running well and is not resulting in adverse impacts to groundwater quality and/or groundwater levels.

- Implement an early warning system utilizing data collected through the monitoring network that helps groundwater managers identify at-risk groundwater users and anticipate potential negative impacts, such as groundwater level declines or worsening groundwater quality.

- If negative impacts are identified from groundwater trading, groundwater managers will need to implement interim and long-term solutions to prevent further lowering of groundwater and adverse water quality impacts to protect drinking water users. Groundwater managers will also need to reevaluate the rules that govern the groundwater market to ensure that future impacts are avoided or mitigated.

- Evaluate mechanisms that can be built into the system that allow for flexibility to adjust over time, to account for changing climatic conditions, and incorporate learning.

- Engage early and often with a diverse group of stakeholders and ensure that engagement includes best practices designed to facilitate the participation of all stakeholders, including providing translation and holding meetings in the evening when people can attend after work.

Appendix

DWR – Department of Water Resources
GSA – Groundwater Sustainability Agency
GSP – Groundwater Sustainability Plan
LAFCo – Local Agency Formation Commission
MSR – Municipal Service Review
SGMA – Sustainable Groundwater Management Act

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