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ISSUE BRIEF

RECHARGE NET METERING TO ENHANCE GROUNDWATER SUSTAINABILITY

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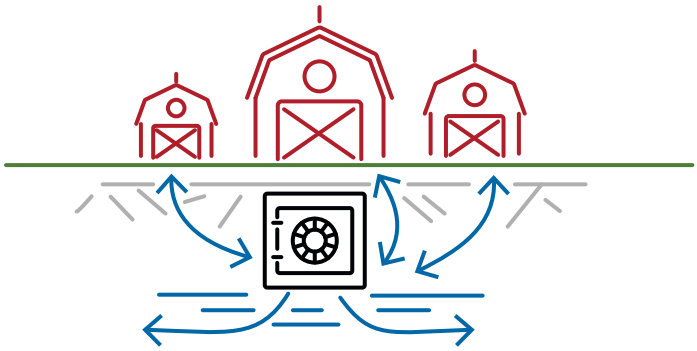
The Groundwater Sustainability Challenge

Groundwater sustainability depends on balancing aquifer inflows and outflows. Extraction (pumping of groundwater, typically for human use) and recharge (inflow of water to an aquifer from the land surface and streams) are central components of this water balance. Often, increasing demands for groundwater are exacerbated by stresses on limited surface water supplies. Changes in land use and shifting climate can result in less infiltration of precipitation into the ground, reducing recharge. Increasing water scarcity has led to increased pumping, and in turn, unsustainable management of groundwater in many basins, resulting in depleted supplies, degraded water quality, and other impacts.

Conservation strategies have reduced demand in some basins, and there are also opportunities for increasing recharge; both strategies can help to tip the water balance towards sustainability. Natural recharge occurs across the landscape, in forests and fields, and below rivers and streams; it is a fundamental hydrologic process that is difficult to measure or control because it varies so greatly in location and timing. Managed aquifer recharge (MAR) is a set of techniques used to improve groundwater conditions by routing more surface water into aquifers. MAR can be applied at many scales, from street corner swales to regional systems. MAR based on the distributed collection of stormwater ("distributed MAR") can be accomplished at an intermediate scale, generating hundreds to thousands of acre-feet/year of infiltration benefit. The promise of distributed MAR stems from its modest cost, and comparative simplicity of design and operation. Distributed MAR projects can be developed on private or public land across a groundwater basin, potentially generating more total benefit than smaller scale installations, and with less cost and complexity than regional MAR systems.

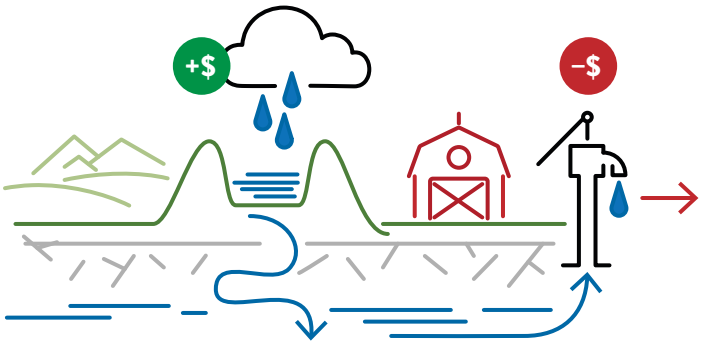
A key challenge for developing distributed MAR projects lies in creating incentives that will motivate landowners, tenants,

GROUNDWATER BANKING



- Users "deposit" water into an aquifer, assumed to function like a central bank
- "Deposits" are associated with a right to withdraw water at a later time
- Water bank might not account for subsurface migration of groundwater
- Bank may be challenged to deliver water when it is most needed, during a drought when inputs are reduced

RECHARGE NET METERING



- Participants infiltrate excess surface water
- Participants rewarded on the basis of quantity of water infiltrated each year
- Infiltration generates rebate on pumping or other use fees
- No right to withdraw infiltration water is implied
- Benefits accrue to the entire basin

Pumping – **Rebate** = Recharge Net Metering

and other stakeholders to participate. Distributed MAR projects can be funded by a limited number of private participants, but public benefits may accrue more broadly. Developing and implementing policies to encourage the creation and operation of distributed MAR systems is a challenge at the frontier of groundwater management.

Recharge Net Metering

Recharge Net Metering (ReNeM) is a strategy that incentivizes MAR by offsetting costs incurred by landowners for operation and maintenance of water collection and infiltration systems that are placed on their land. These costs are commonly associated with loss of use of otherwise productive farmland and periodic maintenance of water conveyance and infiltration facilities. For districts in which water users are assessed fees, agencies can issue rebates of pumping fees (or direct payments can be made). ReNeM rebates are based on system performance, which is linked directly to how much water is infiltrated by each operating project.

ReNeM participants benefit directly through the rebate program; they also benefit indirectly (along with other resource users and regional aquatic systems) because MAR helps to improve and sustain the supply and quality of groundwater. ReNeM participants who host individual projects have no special claim on future access to the groundwater that their projects infiltrate (in contrast to water banking, see figure). The use of a fee rebate based on infiltration is conceptually and technically simple, and consistent with addressing a common-pool resource challenge.

ReNeM is derived from a renewable energy incentive known as Net Energy Metering (NEM), a popular model that encourages adoption of rooftop solar panels. NEM rewards customers for their onsite generation of electricity, by charging them when they draw power from the grid (such as during evening activity), and giving them a credit on their electricity bill when power flows to the grid (such as when the sun is shining and generating excess power). In a similar way, ReNeM rebates link water use to generation of supply for other purposes.

A Pilot Program in the Pajaro Valley, CA

The Pajaro Valley is located in central coastal California, adjacent to Monterey Bay. Fertile, well-drained soils, a mild, Mediterranean climate, and other factors make the area idea for production of high-value crops. The vast majority of domestic, municipal, industrial and agricultural fresh water demands in the Pajaro Valley are met by groundwater, as there is no winter snow pack, no significant surface storage, no rivers or streams with adequate flows during much of the year, and no access to water from outside the basin.

Decades of groundwater overdraft in the Pajaro Valley have contributed to groundwater storage depletion, seawater intrusion, and a decline in groundwater quality. The Pajaro Valley Water Management Agency (PV Water) was created in 1984 to address groundwater overdraft, and is empowered to meter wells, levee pumping charges based on groundwater use, and implement projects to balance the basin. PV Water's current pumping charges are $217-282/acre-foot (af), depending on location. In part of the basin, the agency and municipal partners deliver agricultural users a blend of recycled wastewater, groundwater from farther inland in the basin, and MAR water recovered from a shallow aquifer near the coast. Customers currently pay $369/af for this project water.

Rebate Calculation

The Pajaro Valley ReNeM pilot program uses this rebate equation:

$$Rebate = W_{50} \times (Inf_{tot} - Inf_{inc})$$

where Inf_{inc} is the incidental infiltration that would have occurred without the project, Inf_{tot} is total measured infiltration, and W_{50} is a 50% discount factor to account for uncertainties and storage of soil water, and ensure financial viability.

PV Water completed a public process to develop a basin management plan for the Pajaro Valley Groundwater Basin (PVGB) in 2014. This plan articulates a goal of generating 12,100 af/yr of new supply and conservation measures.

In 2016, the PV Water Board of Directors approved a five-year pilot ReNeM program proposed by the University of California, Santa Cruz (UCSC) and the Resource Conservation District—Santa Cruz County (RCD). The goal of this program is to incentivize ~1,000 af/yr of infiltration benefit across the PVGB, through development of multiple distributed MAR projects using stormwater. The UCSC-RCD team offered to serve as "Third Party Certifiers" (TPCs) for the pilot program, helping to generate interest, select suitable sites, raise capital funding, design and build individual projects, document benefits, and report results to PV Water and participants. PV Water and project partners agree to accept data and interpretations of the TPCs, and PV Water will provide ReNeM rebates (see sidebar *Rebate Calculation*).

The Promise of Recharge Net Metering

There are currently two active MAR installations in the Pajaro Valley, with two more in development. Numerous landowners and tenants have requested property assessments to be part of the ReNeM program. If the ReNeM pilot generates a proof of concept with tangible benefits, it may also shed light how ReNeM could be applied to other settings. Even if ReNeM can be implemented elsewhere, there will be important differences in how programs are structured, so careful documentation of lessons learned is important.

Field measurements show that ReNeM projects can generate significant benefits, even during droughts. The TPC team is designing and deploying systems for accurate measurements, which are critical to both demonstrate efficacy and form the basis for rebates. The TPC team is developing tools and methods to aid in site selection, water quality improvement, and certification of benefits, and is fundraising for existing and future field installations.

In some ways, the Pajaro Valley is ideal for this kind of program. PV Water customers already pay a pumping charge to support groundwater management activities, providing the opportunity to create a rebate program. Pumping charges are unusual in California at present, but this is likely to change as groundwater sustainability agencies consider how to bring their basins into balance. These agencies will require reliable revenue streams to support administrative, technical, and regulatory needs. The Pajaro Valley also benefits from the Community Water Dialogue, a stakeholder group that formed in 2010. A fundamental principal of that effort is a willingness to pursue diverse strategies to balance the groundwater basin.

Conservation programs can reduce the revenue needed by agencies that depend on fees to support basic operations. In some cases, energy utilities have added new fees for Net Energy Metering participants to offset some of these expenses. In contrast, ReNeM could conceivably be revenue positive, while helping put more water into the basin that can be recovered and used by customers.

The TPC team in the Pajaro Valley brings essential capabilities to the ReNeM pilot program, including personnel time, instrumentation, and supplies currently supported by external funding sources. The RCD is well known and respected in the agricultural community, and experienced with project permitting. Ultimately, a stable and reliable funding model will be needed to support ReNeM operations; one goal of the pilot program is to quantify program costs and develop a viable long-term business model. One option is that a portion of the rebate budget be directed to agency staff or consultants to handle TPC tasks. Regardless, involvement of a credible third party may reassure project participants and other stakeholders that the program is being handled objectively and fairly.

ReNeM provides a financial incentive for infiltration that contributes to recharge. Crucially, ReNeM emphasizes incentives for beneficial practices, rather than for a quantified change in storage. As such, the ReNeM program finesses a key technical challenge by linking benefit assessment to infiltration rather than recharge. It is much easier to measure the passage of water from the surface into shallow soil than to measure how much water results in groundwater recharge. More importantly, increasing infiltration is an intrinsic benefit, helping to restore basin hydrology. Eventually, ReNeM may improve the amount and quality of groundwater stored in the basin for the benefit of agricultural, residential, municipal, and environmental systems.

Challenges and Open Questions

Many challenges remain to be resolved if ReNeM is to succeed in the Pajaro Valley, and if the idea is to be implemented elsewhere. Permit requirements for developing and implementing individual ReNeM projects can be significant. Legal and regulatory questions related to both water rights and water quality await answers. "Triple bottom line" accounting may help justify the costs of ReNeM. And the broader success of ReNeM will depend on numerous technical, political, and economic factors that differ enormously from basin to basin.

The ReNeM concept holds promise as a new approach for incentivizing improved groundwater management, providing motivation to answer these and other questions. Ongoing research is examining the viability of ReNeM in the Pajaro Valley and its potential for adoption in other basins in California and in other areas of the world.

Acknowledgements

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See law.berkeley.edu/ReNeM or doi.org/10.15779/J2792D for more details including author affiliations and related reading.