Case for GRIPP site on Groundwater-based Natural Infrastructure

Managed aquifer recharge (MAR) in Nebraska

Using flood river flows to recharge groundwater for irrigation and enhance aquatic habitats

MAR in Nebraska – What is happening?

Nebraska has the most irrigated area of any state in the USA in absolute terms, with nearly 3.4 million hectares irrigated [1]. It is home to intensively irrigated maize and soybean production. Most of the state overlies the High Plains Aquifer, one of the world's largest aquifer systems and a critical resource for the state's agricultural economy.

Despite extensive use of its groundwater resources, Nebraska has largely been spared the steep declines in groundwater storage experienced by its neighbors to the south (i.e., Kansas, Oklahoma and Texas) [2]. However, Nebraska is under pressure from several interstate compacts to mitigate streamflow depletion caused by groundwater pumping in order to protect habitats for endangered species and/or ensure adequate surface water supplies for downstream users (Platte River Cooperative Agreement/Platte River Recovery Implementation Program (PRRIP), Republican River Compact) [3].

Nebraska's Natural Resources Districts (NRDs) (local management agencies, 23 of them in the state) (Figure 1), the state Department of Natural Resources (DNR), private irrigation districts and canal companies have increasingly turned to managed aquifer recharge (MAR) as a means to maintain functional linkages between groundwater and surface water supplies, while making use of excess flows and potentially damaging floodwaters.

Actors involved

Nebraska's NRDs are the entities primarily responsible for groundwater management. They have sole authority to regulate groundwater extraction and to enforce violations of district rules and regulations. The districts are governed by democratically elected boards of directors and managed by teams of technical staff. The state fully supports local governance by the NRDs. In instances where surface water and groundwater are hydrologically connected and fully appropriated[i], the NRDs are required to develop an integrated management plan (IMP) for surface water and groundwater in collaboration with the state DNR. The DNR is responsible for registering groundwater wells and permitting induced groundwater recharge in the state as well as overseeing surface water

quantity. Surface water and groundwater quality (point-source pollution) is monitored by the Nebraska Department of Environmental Quality, while the NRDs are responsible for groundwater quality related to nonpoint source pollution. Other stakeholder groups include public and private irrigation districts and canal companies, PRRIP (a multistate coordinating agency), and other nongovernmental agencies as well as both groundwater and surface water users, especially agricultural producers.

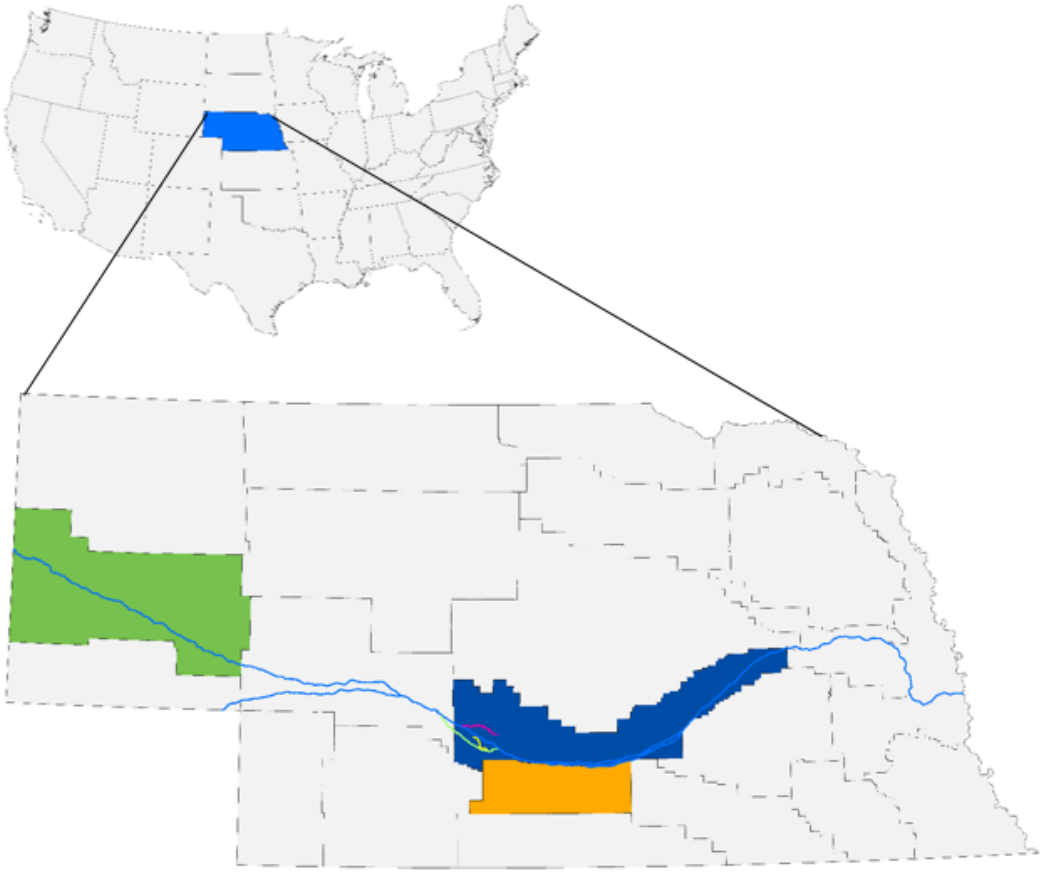

Figure 1. Map of Nebraska, the Platte River (blue line), and the state's 23 Natural Resources Districts (NRDs), including Tri-Basin (orange), Central Platte (blue), and North Platte (green) NRDs. Also shown are three rehabilitated irrigation canals mentioned.

Interventions

Irrigation canals

The majority of MAR projects in Nebraska involve the use of irrigation canals adjacent to rivers to manage surface water flows and facilitate groundwater recharge. For example, the Central Platte Natural Resources District (CPNRD) spent more than USD 15 million

over 5 years to rehabilitate three large surface water irrigation canals in the district. Rehabilitation included clearing and grading the canals as well as the addition of canal crossings and check structures. Goals of the rehabilitation were to: (1) ensure the continued delivery of surface water for irrigation; (2) re-time surface water flows in the adjacent Platte River; and (3) use excess flow diversions from the river to recharge groundwater via the irrigation canals. Groundwater underlying the canals is hydrologically connected to the Platte River, thus ensuring that groundwater recharged via the canals eventually contributes to base flow that is essential for maintaining critical instream flows to the Platte River and multiple endangered species that rely on river habitat, especially during times of drought [4].

In each of the canals, CPNRD has long-term management agreements with the privately owned canal companies and irrigation districts that manage the canal structures. Management involves diversion of off-season excess flows from the Platte River into the canals. These flows are retained in the canals to gradually recharge water to the aquifer. In addition to providing water for recharge, the diversions can be released directly back into the Platte River during periods of low flows. In exchange for using the canals for groundwater recharge, CPNRD has helped farmers fund the rehabilitation of the canals, and in some of the canals contributes to ongoing operation and maintenance of the system (Figure 2). In the first year of project implementation, over 45.6 million cubic meters (Mm^3) of surface water were diverted into three major canals, resulting in 29.6 Mm^3 of groundwater recharge [5]. It is estimated that over 150,000 m^3 of water per month was returned to the Platte River as base flow during the first 3 years of the project diversions [6] [7] [8].

The North Platte Natural Resources District (NPNRD) in western Nebraska also uses irrigation canals to divert excess streamflow. This only occurs when there is the threat of flooding, and under long-term agreements between the NRD and surface water irrigation districts. When there is a threat of flooding and there are no senior calls[ii] on the North Platte River, excess springtime flows are diverted into local canals. The canal companies and irrigation districts are paid by NPNRD to offset the cost of early (pre-season) diversions at a rate per acre-foot (1.0 acre-foot is about 1,234 m^3) of water – this is essentially a lease arrangement. NPNRD receives credit from the state toward the requirements of their IMP for groundwater recharge from the canals. The recharge in the generally quite leaky canals has been estimated as high, at 40% of the total volume (J. Berge, personal communication, June 2018) [9].

Figure 2. Overgrown canal in disrepair (upper left), canal after grading and clearing (upper right), canal section after project completion (lower left) and headworks of the canal after project completion (photos: CPNRD [6]).

Wetlands

The south central part of Nebraska is home to natural playa wetlands, which are sources of groundwater recharge as well as a critical habitat for migratory birds, including endangered whooping cranes. These wetlands are intertwined with irrigated cropland, presenting both challenges and opportunities for ecosystem management. The Tri-Basin Natural Resources District (TBNRD) has worked with the Central Nebraska Public Power and Irrigation District (CNPPID) as well as the US Fish and Wildlife Service's Rainwater Basin Wetland Management District to deliver excess flows from the Platte River to five Wildlife Production Area wetlands. The deliveries ensure additional flooded wetland habitats for migratory birds, while contributing to groundwater recharge under the wetlands. TBNRD has also installed check structures along a small creek in the district to slow streamflow and facilitate groundwater recharge from the creek.

Other approaches

The inter-state PRRIP is the result of the Platte River Cooperative Agreement between Nebraska, Wyoming, and Colorado to manage endangered species habitats in the Platte River Basin. The program's mission is to increase streamflow in the Platte River in the hope of improving habitats for endangered fish and bird species. One way that PRRIP has sought to increase streamflow is through the creation of 6.5 miles of small earthen berms (essentially constructed wetlands) over a 1.7 km^2 area along the Platte River. The berms are being constructed to store excess flows delivered from the Platte River via a pipeline from the CNPPID system. In addition to storing excess water, the berms will provide habitats for endangered species and will facilitate broad-scale groundwater recharge. Groundwater recharge from the berms is hydrologically connected to the Platte River, thus enhancing streamflow beyond the flooding season [10]. The project will contribute 1.6 Mm^3 of recharged base flow [11]. PRRIP is also studying the feasibility of using slurry walls to line existing gravel pits along the same stretch of the Platte River to store excess water from the Platte River for later use [12]. Construction on these projects is scheduled to begin in 2018.

Lessons learned – What's next?

The MAR projects described here share a number of key characteristics. First, collaboration between multiple entities, including upstream and downstream states, has been essential for the development and implementation of each project. Second, many of the projects involved pre-existing canal infrastructure to provide a distribution network for excess flows and distributed recharge. Third, in the institutional setting of the High Plains region of the USA, maintenance and/or rehabilitation of infrastructure is costly, and requires access to relatively large funding sources, including local taxes as well as state and federal sources.

While irrigation canals are most commonly used for MAR in Nebraska, this approach is not without challenges. Excess streamflow eligible for diversion and eventual recharge cannot be guaranteed each year. In years of drought or reduced rainfall, water will not be diverted for storage and recharge. Acquiring land for recharge projects, such as constructed wetlands, has also been a challenge for environmental organizations (e.g., PRRIP) looking to enhance streamflow.

Preliminary results indicate that numbers of endangered bird species have increased since PRRIP began their conservation efforts [13]. However, the exact cause and contribution of recharge efforts to this trend are not certain.

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[i] Wherein existing uses of hydrologically connected surface water and groundwater supplies are equal to, but do not exceed, the available water supplies over the long term.

[ii] In Nebraska, surface water rights are governed by a system of prior appropriation, sometimes summarized as "first in time, first in right." Under this system, the first individual to obtain an appropriation right (i.e., senior water right) to use water for beneficial and reasonable use acquires a right superior to later appropriators (i.e., junior water right). Senior water right holders can make a "call on the river" to claim their legal right to use a certain amount of water, regardless of potential impact on junior water right holders.