HYDROLOGICAL IMPACTS *of* Traditional Community Irrigation Systems *in* NEW MEXICO

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This article compiles recent research results to describe new perspectives on hydrology of traditional community irrigation systems (Figure 1). In New Mexico, these irrigation systems have been in use for centuries, and at least 800 operating ditches exist in the state (OSE, 1991). For the most part, these are unlined earthen canals and convey water to fields that are flood irrigated. Studies have shown that these two aspects can result in significant amounts of water that seep out of the bed and banks of the ditch and below root zones in crop fields, particularly if ditches and fields are composed of sandy or coarse soils (Ochoa et al., 2007). Historically, some water managers have considered this seepage as water that is lost and have encouraged irrigation water delivery and application methods that minimize seepage. Many community ditch irrigators and residents, however, recognize benefits from this seepage: recharging groundwater, keeping shallow wells functioning, and supporting riparian vegetation along the ditches and fields. In situations where it is difficult to have enough flow in the ditch to adequately deliver water to all irrigators, ditches can be lined with impervious materials such as concrete, plastic, or other materials. Where availability of irrigation water is low for individual irrigators or an entire community ditch, sprinkler or drip irrigation methods can be used to conserve water at the field scale.

Our research indicates that in some community ditch-irrigated landscapes, a large-scale reduction in irrigation seepage may lead to unintended negative effects on local aquifers and river flows.

Figure 1. Two traditional community irrigation ditches.

Research on the Hydrology of Community Irrigation Systems

In order to better understand the hydrology of community irrigation systems (Figure 2), in 2002 we began studying water flows in one community ditch system, the Acequia de Alcalde, located in the northern portion of the Espanola Valley in north central New Mexico.

Study results indicate that two key hydrologic functions are provided by these irrigation systems: contributing to shallow aquifer recharge; and providing groundwater return flow to the river. Measurements of shallow groundwater showed that during the 2007 irrigation season, the water table rose about two feet (0.6 meter). Also, a significant amount of this transient water table rise remained past the irrigation season, and because the river is gaining flow from the connected shallow aquifer, it was assumed that this additional water would become return flow to the river. Of river water diverted into the Alcalde community ditch, an average of 33% returned to the river as groundwater return flow—12% originated as seepage from the ditch and 21% originated as seepage from the irrigated fields (Figure 3).

These results indicate that large flows are rapidly being exchanged between the river, irrigation system, and fluvial aquifer.

Past and Present Hydrograph

Prior to large human impacts on parts of the upper Rio Grande, natural features of the river basin resulted in spring snowmelt and storm event runoff being held upstream. These features included river channel meandering, flooding, and even beaver dams. Surface water held upstream would seep into the soil and slowly make its way towards, and then enter, the river as groundwater return flow. During the last two centuries, human alterations and impacts to the river and river flow that counteract these natural features and processes included channelization, levee construction, and beaver trapping.

Aquifer and river connections function to supply stream flow, and the traditional irrigation systems appear to maintain these connections in the upper Rio Grande. Our research indicates that in some community ditch-irrigated landscapes, a large-scale reduction in irrigation seepage may lead to unintended negative effects on local aquifers and river flows.

Figure 4 illustrates a simulation using a system dynamics model, under a scenario in which there are no diversions into community irrigation ditches (as would be the case, for example, if fields are no longer used for irrigated agriculture). In this hypothetical situation, there is less recharge of the aquifer, and so less groundwater return flow to the river. The current irrigation systems actually conserve water by keeping it underground, and the water that seeps from fields and ditches is stored temporarily then released into the river. We have termed this phenomenon "hydrograph retransmission" in which river runoff is stored and released later in the year (Fernald et al., 2010). The spring snowmelt hydrograph is delayed, and much like beaver dams of the past, this storage and release function provides water to downstream users during drier periods when it is most needed.

Water Quality and Riparian Benefits

In addition to effects on water quantity, research has shown that seepage of irrigation water in these systems is beneficial to water quality and riparian vegetation. In one study, water analyses show that ditch and crop field seepage dilute nutrients and salts in resident groundwater, improving the quality of water drawn from shallow wells (Helmus et al., 2009). In another study, it was found that cottonwood poles planted near the ditch survived and were successful, indicating that there is sufficient lateral seepage from the ditch to support riparian plantings (Cusack, 2009). These ditch-side areas could be used to provide additional valuable habitat for wildlife.

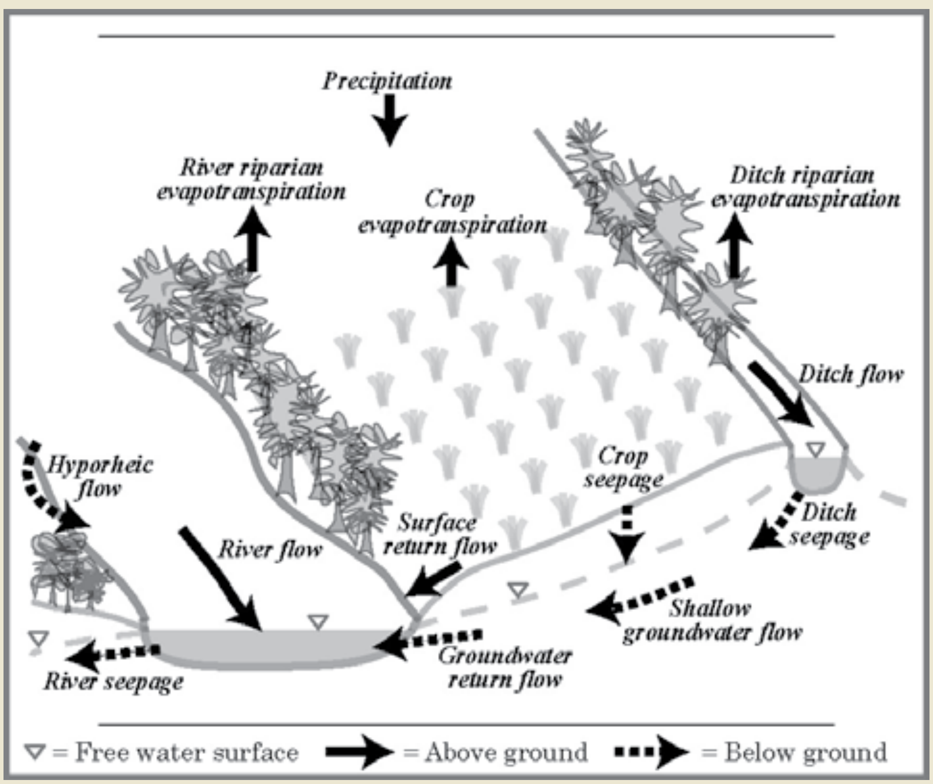

Figure 2. Water flows (indicated by arrows) in a typical irrigated agricultural river valley. Relative magnitudes of flows vary by time and location.

Conclusions

Besides providing for agricultural production, traditional community irrigation systems in New Mexico provide critical hydrologic functions that may be lost if significant amounts of water are transferred out of these systems to non-agricultural uses. Research indicates that a significant amount of water being diverted into the valley irrigation systems returns back to the river. Through seepage into the shallow aquifer, storage in the aquifer for 1-3 months, and then release to the river as groundwater return flow, these systems effectively take spring and summer runoff from the river and retransmit this flow to the river later in the year.

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Additional Resources

New Mexico State University, Surface Water - Groundwater Interactions in Irrigated Floodplains in Northern New Mexico
http://aces.nmsu.edu/academics/waterresearch/home.html

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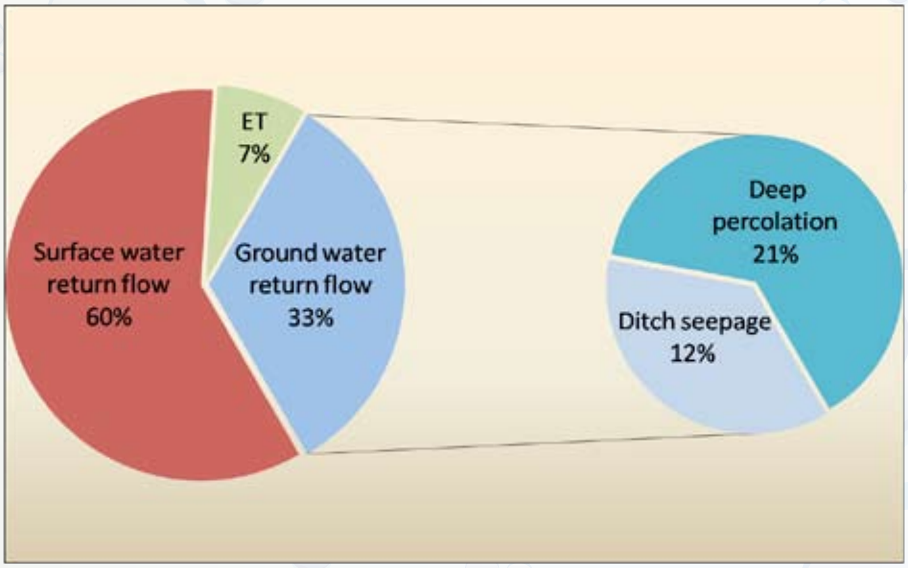

Figure 3. Three-year averaged water budget of the Alcalde community ditch.

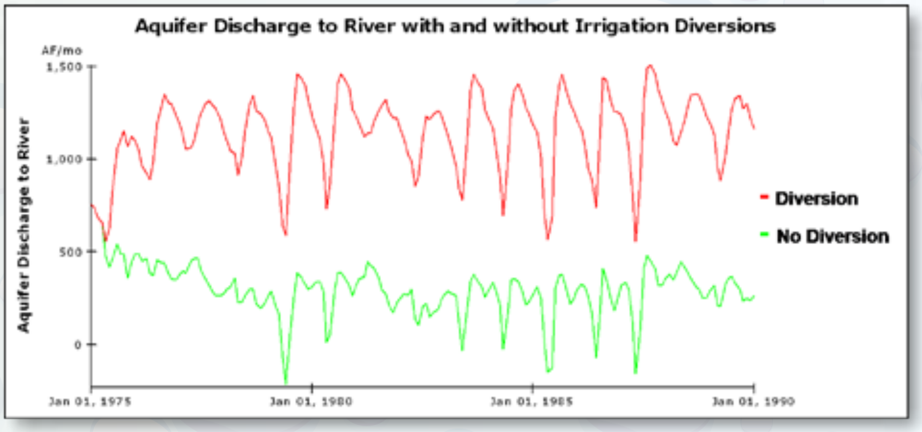

Figure 4. Effects of diversion on groundwater return flow to river. This figure is posted ahead of print (with permission from the American Society of Civil Engineers) (Fernald et al., 2010).