CONCEPTUALIZATION OF GROUNDWATER IN THE GLEN ROSE FORMATION, MAVERICK BASIN, TEXAS

TWDB Contract Report 230001271-2 Summary | February 2025

BACKGROUND

In November 2021, the Railroad Commission of Texas had a press release bringing attention to fresh- to slightly-saline water production from Glen Rose Formation wells in Maverick County (Railroad Commission of Texas, 2021) from depths of over 5,000 feet. Because of the significant interest in this water resource, the TWDB contracted with INTERA Inc. to document relevant data and background geology into a report to serve as a starting point for future research. The contracted report includes an assessment of the available data, overview of the geologic setting, hypothesis for the nature of recharge and flow, suggestions for aquifer tests, and the available water quality data used to delineate a tentative aquifer boundary (data included as an appendix). Currently the Glen Rose Formation of the Maverick Basin is referred to as the Maverick Basin aquifer, and the tentative aquifer boundary (Figure 1) overlaps portions of regions L and M regional water planning groups in Maverick, Zavala, and Dimmit counties.

WELL DEVELOPMENT

Since the 2000's, Glen Rose Formation production wells in the Maverick Basin began to co-produce anomalously high volumes of water along with oil. This water was reported to have very low total dissolved solids (generally 1,000 to 2,000 milligrams per liter), which is unusual for water co-produced with oil and gas which is often extremely saline. The Railroad Commission of Texas became aware of this water when operators and private land owners began submitting applications to convert oil wells to water wells in this field (referred to as P-13 applications). In addition, there are numerous wells disposing of low salinity water produced from the Glen Rose Formation as surface discharge (Figure 1), and many of the these wells flow to the surface without a pump (artesian).

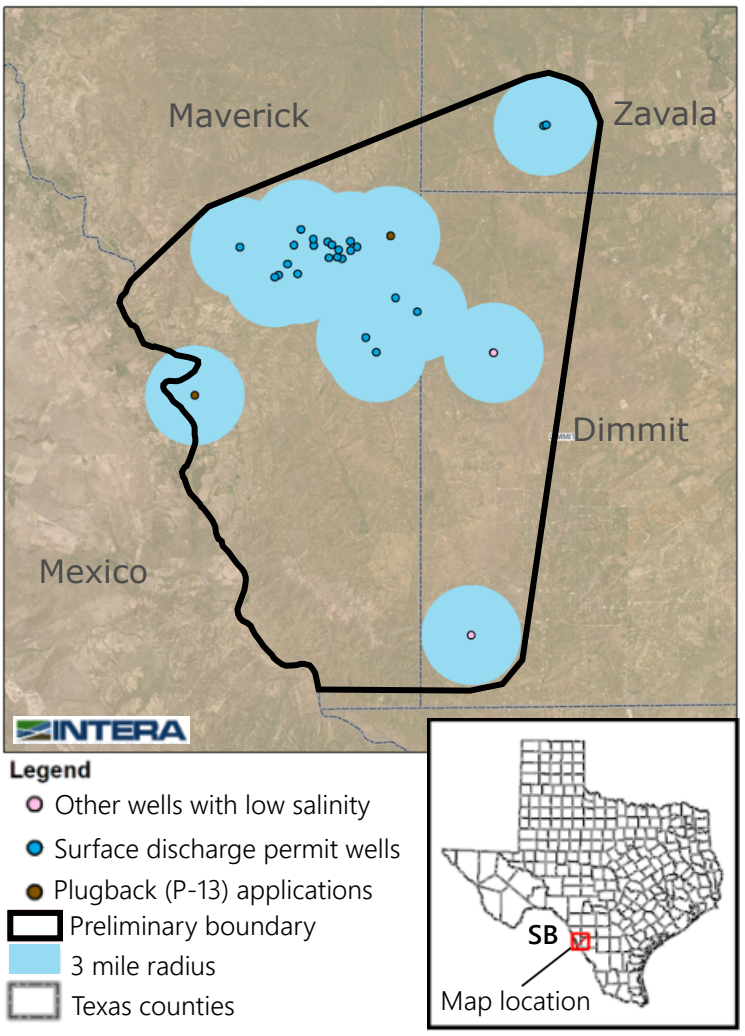

Figure 1. Preliminary aquifer boundary that encircles all areas within three miles of a permit application for water discharge (blue), P-13 application (brown), or wells indicating low total dissolved solids (pink) from the Glen Rose Formation. 'SB' in the inset map of Texas is the location of the Serrania del Burro Mountains in Mexico.

GEOLOGIC SETTING

Within the Maverick Basin, the Glen Rose Formation consists of shelf carbonates with occurrences of patch reefs from Maverick County into central Texas (Scott, 2004). After deposition within the Maverick Basin, the Laramide Orogeny compressed the area forming the Chittim Anticline, Zavala Syncline, and other related

folds and faults, which are the major structural elements in the area. 3D seismic imaging of the Glen Rose Formation reveals porosity anomalies that are likely the result of hydrothermal alteration along fracture pathways (Scott, 2004). High volumes of fresh- to slightly-saline produced water from the Glen Rose Formation aligns with these porosity anomalies as seen in map view, whose linear patterns reveal a significant fracture zone which likely serves as a conduit for flow (Figure 2).

AVAILABLE DATA

Geophysical logs and seismic data are abundant within the Maverick Basin for mapping the structure of the Glen Rose Formation, with numerous geophysical logs available to the public. Seismic data is for the most part proprietary and expensive to lease, though some images have been published such as from Scott (2004) which provide important insights into the character of the Glen Rose Formation. Water quality data is the most important source of information defining the extent of the Maverick Basin aquifer. The contracted report includes five wells with complete water quality analyses and 12 additional wells with reported total dissolved solids (either from surface discharge wells or reported from old drill stem tests) that are mostly fresh to slightly saline, and sourced from the Glen Rose Formation. Oxygen and hydrogen isotope data from Maverick Basin wells and from springs and rivers in Mexico are also available, which provide information on the potential source of recharge. Reporting of percent oil, gas, and water produced from petrolem wells, and the locations of permitted surface discharge provide additional insight to the potential extent of the aquifer.

AQUIFER CONCEPTUAL MODEL

The current hypothesis is that recharge occurs in the Serrania del Burro Mountains to the west in Mexico, and is transmitted through the Glen Rose Formation where it eventually encounters zones of enhanced porosity in Maverick County (Figure 3). The only known discharge in the Maverick Basin is through oil wells as produced water. Recharge occurring via outcrop zones in Texas is unlikely based on very low water volumes observed in most Glen Rose Formation gas wells between the study area and the Glen Rose Formation outcrop to the north-northeast in Texas. Similarities of the oxygen and hydrogen isotopic data between the surface water in Mexico and produced water in the Maverick Basin supports the idea of meteoric (surface) recharge sourced from Mexico.

CHALLENGES

The tentative aquifer boundary is delineated by a three-mile buffer zone around each well producing water with low total dissolved solids, and by connecting the buffers west into Mexico (Figure 1). However, a more hydrogeological-based aquifer boundary may be to include all areas where the groundwater has a total dissolved solids less than 10,000 milligrams per liter, and where oil and gas wells are producing over 90% percent water by volume, which would require additional data and research.

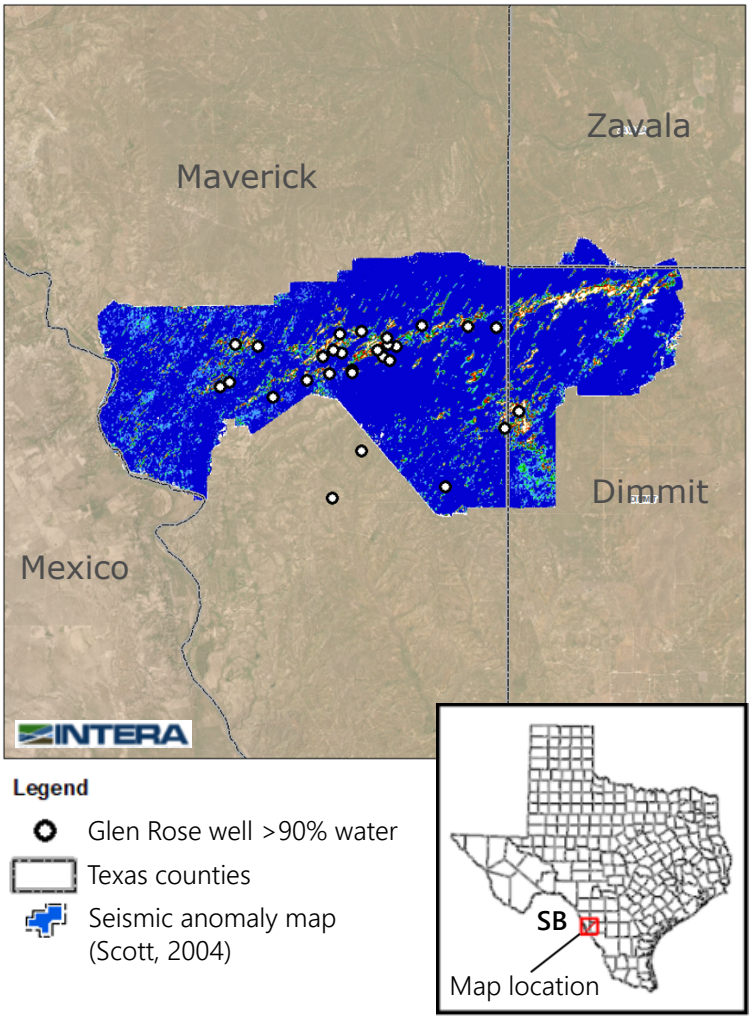

Figure 2. Seismic anomaly map and petroleum wells in the Glen Rose Formation producing over 90% water by volume (Scott, 2004). 'SB' in the inset map of Texas is the Serrania del Burro Mountains.

Insufficient data exists to properly characterize the aquifer with traditional hydraulic parameters like transmissivity, storage, or hydraulic conductivity. Because groundwater flow and storage may be highly localized in fracture systems, single well tests are likely insufficient to extrapolate aquifer properties, and therefore INTERA recommends a thorough series of aquifer tests to conceptualize the hydraulic conductivity and storage of the aquifer. To conduct the tests, INTERA suggests the use of monitoring wells at key locations and long-duration, multi-well aquifer tests specifically designed to evaluate the complex flow dynamics of the system, which are further detailed in the contracted report. Utilizing existing petroleum wells completed in the aquifer for the aquifer tests is recommended so as to be economical.

A unique challenge for the Maverick Basin aquifer is the need to manage small but variable concentrations of liquid hydrocarbons, and the potential for occasional hydrocarbon spikes during well operations. Building in redundancies and additional surge capacity as part of the treatment design will be important to accommodate these potential fluctuations.

Monitoring and regulating injection-well activity in the Glen Rose Formation poses another challenge for the development of the Maverick Basin aquifer, though currently there is only one active injection permit in the Glen Rose Formation within the preliminary aquifer boundary. Since this water source has been identified, the Railroad Commission can actively protect the aquifer from the injection of injurious water. However, because the aquifer boundaries are only loosely defined, the protected aquifer boundaries will need to be redefined as additional water quality data becomes available.

Lastly, the Glen Rose Formation is most likely a trans-boundary aquifer at depth with Mexico. Groundwater development in Mexico may be less capital intensive due to the shallower depth of the aquifer, which could result in increased pumping from the Mexican portion of the aquifer, potentially impacting water availability for users in Texas.

Ultimately, the successful development of the Maverick Basin aquifer will require a concerted effort by researchers, regulators, water managers, and stakeholders to fill critical knowledge gaps, address key challenges, and develop a framework for sustainable management. With the right approach, this water resource could play a role in southwest Texas.

REFERENCES

Draper, C., Grisak, G., and Liu, C., 2025, Conceptualization of Groundwater in the Glen Rose Formation, Maverick Basin, Texas: INTERA Inc, Contract report 2300012710-2 to the Texas Water Development Board, 96 p.

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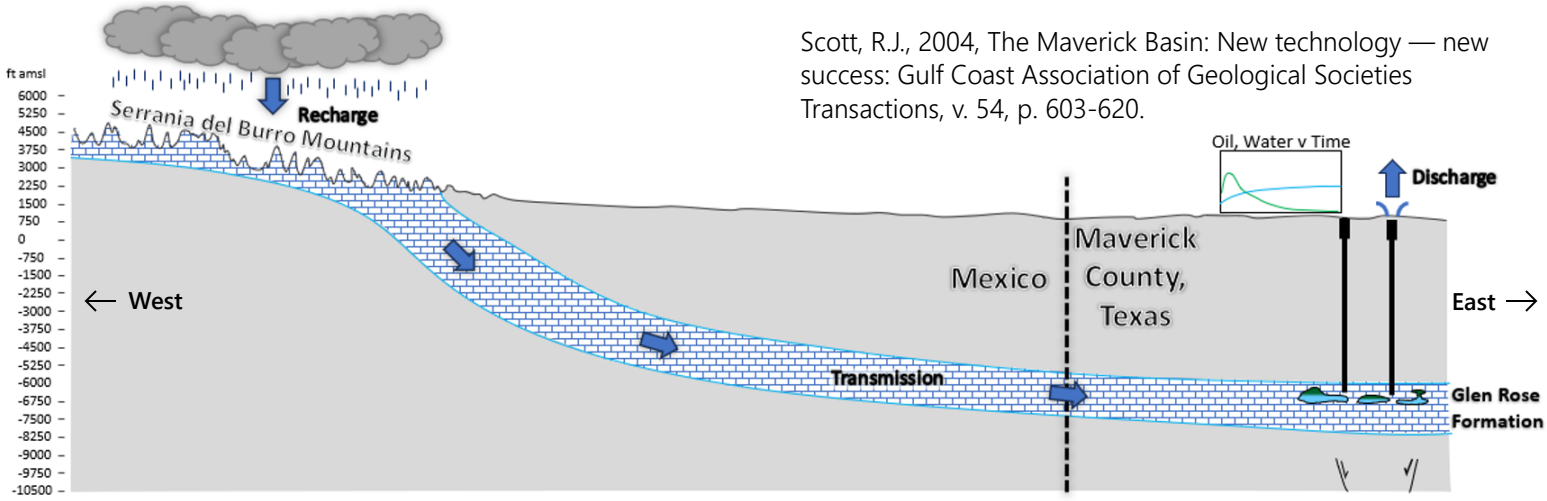

Figure 3. Simple conceptualization of the modern configuration of the Maverick Basin aquifer. It is hypothesized that recharge occurs in the Serrania del Burro Mountains to the west in Mexico and is transmitted east through the Glen Rose Formation where it eventually encounters zones of enhanced porosity in Maverick County. The only known discharge is through oil and water wells. Oil is green and water is blue in the Oil, Water v Time graph.