LRE WATER

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CONNECTING WATER TO LIFE

TERRY RANCH PROJECT

AQUIFER CHARACTERIZATION STUDY

GREELEY, COLORADO

BACKGROUND

LRE Water conducted a hydrogeologic investigation of the Upper Laramie Aquifer (ULA) underlying the Terry Ranch for the City of Greeley, Colorado. Terry Ranch is an 8,400-acre bison ranch that straddles the Wyoming and Colorado border. The City of Greeley was considering entering into a private-public partnership to purchase the groundwater rights underlying the property, and it needed to evaluate the feasibility of utilizing the aquifer for municipal water supply and treated surface water storage. The project was completed over a nine-month period, and involved an extensive investigation of the aquifer's productivity, water quality, and storage potential.

INNOVATIVE DELIVERABLE

The results of the investigation needed to be easily shared within the City of Greeley and made available to the public for review. LRE Water developed a GIS STORY MAP to readily share and convey the results of the investigation.

TERRY RANCH

AQUIFER PRODUCTIVITY

LRE Water conducted multi-day aquifer tests at five production wells on the property. Water levels were monitored continuously during pumping and recovery to estimate aquifer properties, and groundwater samples were collected at the wellheads and specific depth intervals for water quality analysis. The findings of aquifer testing included:

- Sustainable well yields vary across the property and range from 110 to 590 gallons per minute (gpm). Well productivity tends to be higher in the northern portion of the property where the aquifer is thickest.
- The aquifer has two hydraulically separated producing zones: 1) high-producing "upper" zone, and 2) a low-producing "lower" zone. Approximately 60% to 90% of the aquifer yield is derived from the "upper" zone.
- The aquifer is capable of accommodating the City of Greeley's anticipated rates and volumes of groundwater pumping and aquifer recharge/storage.

WATER QUALITY

Composite and depth-specific groundwater samples were collected from five production wells and two monitoring wells. Over 7,000 individual analyses were conducted for 577 water quality parameters. LRE Water compiled the lab results to a water quality data dashboard, which facilitated data sharing, filtering, sorting, and exporting.

Three constituents of interest were identified, including uranium, gross alpha particle activity, and manganese. Prior investigations revealed that the ULA underlying Terry Ranch has naturally-occurring uranium. One of the core objectives of LRE Water's investigation was to characterize the extent of the uranium and to determine if it is stratified. This was accomplished through a combination of spectral gamma logging, Corehole Dynamic Flowmeter (CDFM) and HydroPhysical logging, and depth-specific (zonal) sampling. Results indicated that, although uranium concentrations varied with depth, the uranium was not restricted to a discrete aquifer zone(s). Hence, the uranium could not be avoided through selective well design and would need to be removed through treatment.

GEOCHEMISTRY

Reactions between the aquifer material and treated surface water can result in dissolution of trace metals. Understanding the mineralogy of the aquifer materials and the abundance of trace metals was needed to evaluate the risk of metal dissolution during aquifer storage.

Aquifer material samples were collected from selected producing/storage zones and submitted for bulk x-ray diffraction (XRD) mineralogical analysis and trace metal quantification using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). XRD analysis indicated that the aquifer materials are dominated by quartz, plagioclase, potassium-feldspar and muscovite, which are consistent with the depositional environment and source materials. ICP-MS analysis indicated that the concentrations of trace metals in the aquifer materials are within normal ranges and do not pose a risk to aquifer storage.

Other techniques were employed to characterize the aquifer geochemical conditions and to predict potential changes during ASR operations, including Piper and Stiff diagrams, and Eh-pH diagrams. The waters' pH, Eh, dissolved oxygen, and temperature characteristics were used to construct Eh-pH diagrams. The plots showed that uranium and arsenic are stable in the aqueous phase for both the groundwater and the City of Greeley's treated surface water, corroborating the results of ASR pilot testing.

ASR PILOT TESTING

Demonstrating the feasibility of aquifer storage at Terry Ranch became critical to the City of Greeley's decision-making. LRE Water devised a plan to conduct a short-term ASR pilot test, and prepared an EPA UIC Rule Authorization application. The application was prepared, submitted, and approved by the EPA in less than two months.

The ASR pilot test needed to be conducted using the City of Greeley's treated surface water, but its water treatment plant is over 35 miles away. Water was delivered via truck and stored on-site, which limited the rate, volume, and duration of testing. A monitoring well was used for the pilot test, instead of a high-capacity production well, due to the water supply constraints. Two cycle tests were conducted: a one-day test, followed by a three-day test. Field water quality parameters were monitored, and samples of recovered water were collected for water quality analysis.

One of the objectives of ASR pilot testing was to evaluate the potential for mobilizing uranium and arsenic in the aquifer. Uranium, arsenic, and chloride concentrations were monitored in the recovered water and plotted to see if uranium and arsenic concentrations trended similarly to chloride. Uranium and arsenic behaved similarly to chloride and gradually trended from the recharge source water concentrations to the native groundwater. C/Co plots were also used to evaluate uranium and arsenic mobilization, where C is the measured concentration of a constituent and Co is the concentration of that constituent in the native groundwater. The uranium and arsenic C/Co plot trends mirrored that of chloride, which was further evidence that neither uranium nor arsenic were being mobilized during ASR operations.