Experimental Study of Injection Interval Hydraulic Isolation from Overlie Formation at the Siberian Chemical Complex Disposal Site Using High-Accuracy Hydraulic Head Measurements

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High-accuracy groundwater head measurements were performed in September 2002 during temporal termination of waste injection to study leakage through semipermeable layer D at injection area 18 of the disposal site at the Siberian Chemical Complex. Special equipment (the "Uroven-1M," developed by the design firm Geophyspribor of the Russian Academy of Sciences), which automatically measures and records monitoring parameters, was installed at injection area 18. This equipment has sensors for water-level and temperature measurement in monitoring wells and a sensor for atmospheric-pressure recording. Accuracy of water-level measurements is within 0.5 mm. The water level sensors were installed in wells T-8 and T-22 (which open to aquifer IV and overlie injection aquifer III). Spatially, well T-22 is located about 10 m from the nearest injection well, N-13, and is 500 m from monitoring well A-44, which is open to injection aquifer III. In the vertical cross section, the screened intervals of wells T-22 and T-8 are 30–40 m above the screened intervals of injection and monitoring wells in aquifer III. The interval between aquifers III and IV, which is composed of clay deposits with sand lenses, is marked as semipermeable layer D. Water level, temperature, and atmospheric pressure were recorded digitally at a frequency of once every five minutes during one month of temporal termination of waste injection.

A numerical simulation of a one-month injection termination period performed before the sensors were installed indicated that, as is typical for this situation, groundwater head drawdown was about 10 meters in aquifer III and in the range of 0.1–10 mm in aquifer IV. The drawdown in aquifer IV depends on hydraulic conductivity and elastic storage of clay and sand units that compose semipermeable layer D. The maximum modeling drawdowns were obtained in the simulation run with maximum acceptable hydraulic conductivities for this site and minimal storage. Thus, the accuracy of the Uroven-1M sensor allows monitoring of the hydraulic response of aquifer IV upon termination of the injection for certain (unfavorable) combinations of hydraulic parameters that comprise semipermeable layer D.

Processed measurement results included decomposition of hydrographs in the wells by estimating water-level response to atmospheric pressure time variation and the periodic response of Earth tides. After eliminating these effects, a trend analysis of the water level was performed to estimate its directed change (drawdown), which is the hydraulic response to termination of the injection.

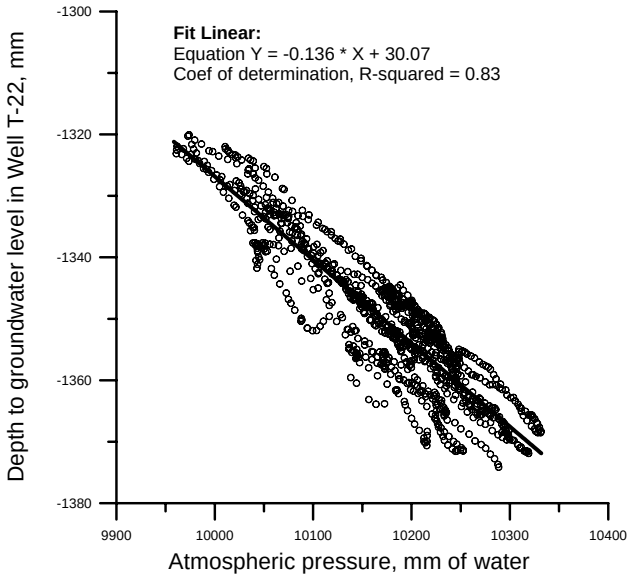

Figure 1. Hydraulic response of well T-22 to atmospheric pressure fluctuation.

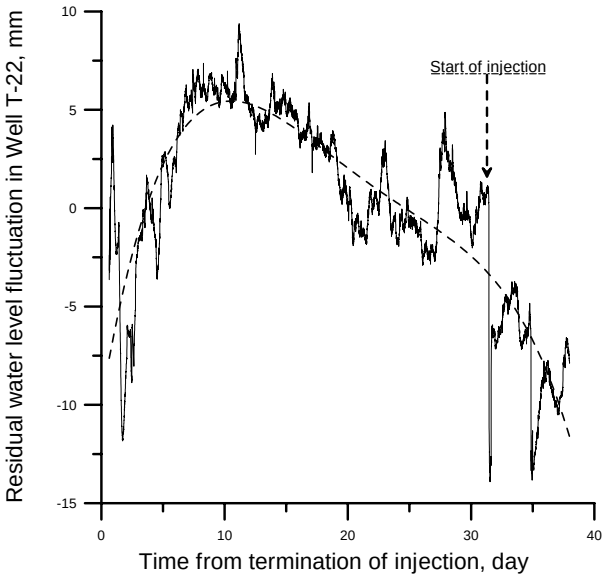

Figure 2. Residual fluctuation of groundwater level fitted by polynomial trend (dash line).

The results of high-accuracy measurement processing indicate the following:

1. During the entire measurement period, water levels fluctuated synchronously in both monitoring wells with an amplitude of a few centimeters. Note that in the captured injection interval of A-44 (the monitoring well nearest to the sensor wells), the maximum observed drawdown of groundwater head was 6.5 m. The standard deviation of fluctuation (~12 mm) related mostly to variation of atmospheric pressure (see Figure 1). After elimination of atmospheric response, the residual standard deviation became 3.9 mm. Earth tides for the periods 12 and 24 hr are recognized in level fluctuations, but their maximum amplitude is less than 1 mm.
2. Residuals after elimination of atmospheric pressure and Earth tide responses water level fluctuations do not have a recognized downward trend in both observation wells (see Figure 2). This result is additional proof of good isolation of the injected interval from overlying formation at the Disposal Site.

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