LESSONS LEARNED FROM HYDRAULIC STUDIES OF A FRACTURED BEDROCK FORMATION

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ABSTRACT – Four years of hydraulics studies at the Bedrock Bioremediation Center Pease New Hampshire study site has resulted in a variety of new understanding,: sometimes hard-learned lessons and other times reinforcements of decades-old knowledge.

A sampling experiment was performed to compare the various devices and methods that can be used to sample open boreholes. The primary result of the study was that of the five methods studied, no two were statistically comparable to each other. In addition, concerns about the compatibility of the materials that constitute the sampling devices are no less important now as when the issues were raised in the 1980's.

Hundreds of slug tests and dozens of pumping tests were conducted. The initial evaluation of the data using traditional means resulted in hydraulic parameter sets (transmissivity and hydraulic conductivity) being related to the type of test: the slug tests generated higher hydraulic conductivity that the pumping tests. Further inspection of the data and the methods made it apparent that the homogeneous theoretical models (Theis, Jacob, Cooper, and Hantush) were not reflected by the data. For example, in curve-fitting slug test data to Cooper type curves, the type curves explained either early time or late time data, but not both. A simple, one-dimensional, heterogeneous, finite-difference model was developed and it not only described all the slug test data, but also revealed that consistent hydraulic parameters could reproduce both slug test and pumping test data. This type of conceptual model (heterogeneous) may also shed light on the size of the "Representative Volume Element" for fractured rock systems.

Since the test site possessed multiple wells that could be depth-isolated, large displacement (drawdown) slug tests were employed at the site. The heterogeneous numerical model also described this data. More importantly, the large displacements were detected at monitoring wells hundreds of feet away, thereby yielding more accurate measures of larger scale hydraulic parameters without the need of a pumping test.

A site-wide pumping test was devised around the existing pump and treat remedial strategy that had been operating for years. By turning off the system and waiting one week and then restarting the system, the effects of long-term pumping versus short-term pumping could be compared. A dramatic result was that the short-term pumping test (7 days) in both overburden and bedrock did not generate the same shape of the cone of depression as the long-term pumping. This is a consideration that should be factored in to the interpretation of piezometric data as well as the hydraulic design of remedial measures.

A new type of test, the gas injection test, was demonstrated and may prove useful as one other method to detect hydraulic connections between wells or within fractured rock systems. The synthesis of all of these lessons was the development of the conceptual hydrogeologic model for the bedrock.