Injection Well Expert Facts—For Case Discussion
Expert Facts:

You have been retained by a citizen's group to testify regarding your opinions on the ability of a pressurized injection of industrial wastewater into deep, sealed strata to make its way into drinking water and recreational surface water. The scope of your work includes analyzing the appropriateness of modeling assumptions and parameters used to determine the potential for contamination of Underground Sources of Drinking Water and other formations.

The Applicant/Permittee has applied to the State regulatory agency for a permit to inject industrial wastewater into a deep geologic formation. The State decided to issue the permit, but a group of citizens have appealed the issuance to the State Environmental Hearings Board. The citizens are claiming that the permitted activity will adversely affect their drinking water supplies, which include an aquifer and surface water above the injection interval. The well at issue is one that had been drilled, perforated, and then sold to the Applicant after the prior permit had failed to be renewed. The well at issue, therefore, is an existing well (WDW-315).

The relevant regulatory language is: The Agency must consider if the proposed injection well area is geologically suitable based on the following criteria:

(A) analysis of the structural and stratigraphic geology, the hydrogeology, and the seismicity of the region;
(B) analysis of the local geology and hydrogeology of the well site, including, at a minimum, detailed information regarding stratigraphy, structure, and rock properties, aquifer hydrodynamics, and mineral resources; and
(C) a determination that the geology of the area can be described confidently and that limits of waste fate and transport can be accurately predicted through the use of analytical and numerical models.

An Applicant must show that the proposed injection zone has "sufficient permeability, porosity, thickness, and areal extent to prevent migration of fluids into USDWs or freshwater aquifers."

Here is what you know and based your opinions on: The Applicant modeled an area of review that extends 14,300 feet from WDW-315, which is 1,100 feet beyond the Applicant's area of review. If the fault at 4,400 feet is modeled as transmissive, the cone of influence would extend to 3,170 feet and encompass 38 wells with 18 of those wells having no total depth information on file with the Railroad Commission. Under those assumptions, the area of review would extend 0.2 miles beyond the 2.5 area of review suggested by the Applicant, and at least one well has a depth of 12,492 feet and 18 wells are without any data on well depth or closure.

The operational considerations related to injection rate, pressure, compatibility of the injectate with the formation and formation brines, and potential endangerment of Underground Sources of Drinking Water are all based on an accurate understanding of the reservoir mechanics. Reservoir modeling is done to predict the pressure increases that may occur within the injection reservoir during the projected life of the proposed injection well or wells." Various data inputs are required to conduct a reliable pressure model, including conservative values for reservoir porosity, permeability, thickness, and area extent to predict the pressure increases that may occur in the injection zone over the life of the injection well.

The fact that WDW-315 is an existing well allows the Agency the benefit of the results of a fall-off test, or a test that provides more accurate injection zone characteristics such as permeability and the existence of pressure boundaries, that was conducted when the well was first completed by a previous applicant. The results of that fall-off test indicate a permeability in the receiving interval that averaged 81 millidarcies. The Applicant assumed a permeability of 500 millidarcies based on core samples "taken from the well." The Applicant's engineer stated in response to interrogatories that he used data from core samples instead of data from the fall-off test because the Applicant intends to perforate more than the original 90 feet of the wellbore, namely the Applicant intends to perforate part of the Lower Cockfield due to its greater sand content. Currently, approximately 90 feet of the wellbore is perforated between 6,184 feet to 6,372 feet, and the Applicant intends to perforate 45 more feet of the wellbore above the current perforation.

You know that the 14-foot core sample was taken from 6070-6084 feet, which is in a single sand in the Lower Cockfield, and was then used to make assumptions about the entire injection interval. Also, the additional 45 feet of perforation would need to have a permeability of 1400 millidarcies or more to provide an average for the entire interval of 500 millidarcies, and such a permeability value is unlikely based on the core samples.

Agency rules require Class I injection wells to be sited such that the confining zone "is laterally continuous and free of transecting, transmissive faults or fractures over an area sufficient to prevent the movement of fluids into a USDW or freshwater aquifer." The Applicant stated in response to interrogatories that they assumed the fault at 4,400 feet to the south of the well site was "in communication with" or transmissive between the Upper, Middle and Lower Cockfield. According to the Applicant, the transmissivity assumption in their modeling would show a greater predicted distance for the waste to travel. The waste plume radius, over the course of 30 years, would extend 2,700 feet under the Applicant's model, which does not reach the fault at 4,400 feet. The Applicant has stated that they believe the two faults identified in the applications are both laterally and vertically transmissive. The Applicant states that a fault is transmissive if less than 25 percent shale exists on either side of the faulted horizon. The Applicant believes the fault at 4,400 feet extends approximately 30 feet into the shale between the Upper and Middle Cockfield. The thickness of the Middle Cockfield is approximately 400 feet and the Upper Cockfield is 300 feet.

You believe the fault at 4,400 feet to the south of the well is non-transmissive because vertically alternating sand (50 percent) and shale (50 percent) strata in the Middle and Lower Cockfield cause two sealing mechanisms along the fault. First, the sand-to-shale juxtaposition across the fault, and, second, shale smearing along the fault plane both cause a low permeability barrier of shale that restricts both fluid and pressure movement laterally and vertically. In distinguishing the 4,400 foot fault from other faults in the Conroe oil field, you believe that some faults in the Conroe Field do not provide a hydrocarbon trap, but this fault has trapped hydrocarbons. The only mechanism for such trapping to occur would be a sealed fault according to you.

You have a hunch that the Applicant will question why hydrocarbon production would not have occurred in the Middle and Lower Cockfield if the fault were, indeed, transmissive. You believe, however, that those sands never had hydrocarbons that migrated through them to come up against this particular fault. As the upslope side of the fault is to the northwest, and oil production has occurred on that side of the fault, the advent of oil production could be attributed to an "attic" between the Jackson Shale and the Upper Cockfield. While you believe this is a possibility, you also know that the oil and gas column is greater than the amount of attic at that position.

Your concerns would be alleviated if a full completion report did the following: incorporates the results of the current fall-off test or new fall-off test; demonstrates that the modeling as currently presented is conservative or the modeling was redone to show a new cone of influence; addresses wells within that revised cone of influence; and determines whether the fault at 4,400 feet is a lateral pressure boundary. However, completion reports are only required for new wells according to the regulatory language.