IPCB Additional Comments, January 16, 2013

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These comments are provided as clarification of my testimony at the Illinois Pollution Control Board hearing of October 30, 2012 in DeKalb, IL and with regard to testimony by Mr. Trainor at the IPCB hearing of November 14, 2012 in Elizabeth, IL.

Contrary to Mr. Trainor's statement that "all groundwater is reduced" and therefore no bacteria can survive in it, it has been my experience and the experience of most geochemists who have sampled shallow groundwater that groundwater in open systems (sand and gravel and karst aqiufers) is oxygen enriched and typically contains abundant bacteria (both natural and human related) and nitrate (a ion that is rapidly converted to nitrogen gas in a reduced groundwater environment). During sampling events in southwestern Illinois involving over 50 wells drilled into karst limestone to depths of over 200 feet, and 15 karst springs in southwestern and northwestern Illinois, oxygen contents of the well and spring waters were similar to those of surface water (i.e., between 5 and 10 mg/L dissolved oxygen). In this area, we found that all of the springs and **two thirds** of the private wells contained enteric bacteria and all contained surface-borne contaminants. Using the species of bacteria as an indicator, we concluded that the sources of bacteria were both livestock and human. Recently, I teamed up with Dr. Walton Kelly (Illinois State Water Survey), Dr. Wen-Tso Liu (Dept. of Civil and Env. Engineering, University of Illinois), and Ya Zhang (a graduate student under Dr. Liu) and conducted research in karst areas of Illinois, Missouri, Kentucky and Wisconsin using genetic biomarkers. The biomarkers, bacterial indicators and groundwater chemistry revealed the same mixture of livestock and human enteric bacteria present in the karst aquifers of all of these states.

Creviced carbonate bedrock forming karst aquifers create a class of aquifers referred to as *open systems*. Groundwater within *open systems* is oxygenated and tends to remain so. In areas with a high degree of karstification, it is not uncommon to find small fish swimming within bedrock wells. In sand and gravel deposits near streams, amphipods have been observed living within the groundwater of the sand and gravels at depths of over 15 feet (Tim Young, ISGS, personal communications). All require oxygen to survive. *Closed systems* are those aquifers that are somewhat isolated from surface recharge either by depth or by low-permeability layers overlying them (e.g., shale). Groundwater in *closed systems* tends to be oxygen poor and progressively become more chemically reducing with greater isolation and/or depth.

Mr. Trainor suggested that characterization using dye tracing and trenching of sites underlain by karst aquifers was unnecessary and that these aquifers were dominated by porous media flow. Regarding characterization techniques and as I stated in my original testimony, it is well known by karst hydrologists that dye tracing and trenching is absolutely essential for site characterization of flow paths and flow rates in a karst area; karst aquifers are not dominated by

porous media flow, but by crevice and conduit flow. The difference is that crevices and conduits provide focused pathways for groundwater to travel very quickly and in directions that may be counter to what would be expected in porous media flow. For this reason, groundwater flow in karst aquifers cannot be characterized and modeled without a thorough inspection of the bedrock (e.g., via excavations) and dye tracing (techniques recommended by karst hydrologists).

Ms. Manning from the Illinois Department of Agriculture asked what the cost to the "average farmer" would be for determining the depth of soil on their property. An approximate depth of soil or depth to bedrock would be available from the Illinois State Geological Survey (ISGS) upon request. The information would be based on existing drilling data and private well data available in the ISGS on-line data base.

Finally, recent work by Dr. George Roadcap of the Illinois State Water Survey showed that surface-borne contaminants were entering sand and gravel aquifers that lay beneath 50 to 60 feet of clay-rich glacial till in northeastern Illinois (Dr. G. Roadcap, ISWS, personal communications). Currently, it is not clear how the contaminants reached the protected aquifers, but possible vectors include deep, continuous fractures in the till (macropores) and/or abandoned wells. Both are common in Illinois and constitute points of entry to underlying aquifers that were previously thought to be well-protected from surface-borne contaminants. This new information highlights the importance of a relatively thick soil zone overlying karstified carbonate rock. Instead of tens of inches thick, the soil should be tens of feet thick in order to provide some protection to the underlying groundwater.